Synthesis of Studies in the Fall Low Salinity Zone of the San Francisco Estuary, September-December 2011

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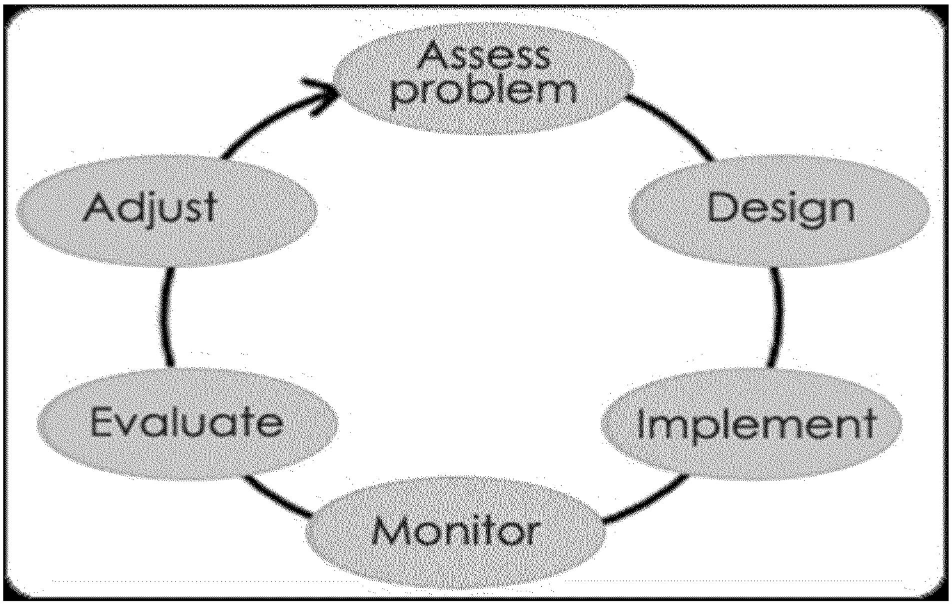


Figure 1. A schematic of the adaptive management cycle (modified from Williams and others 2009).

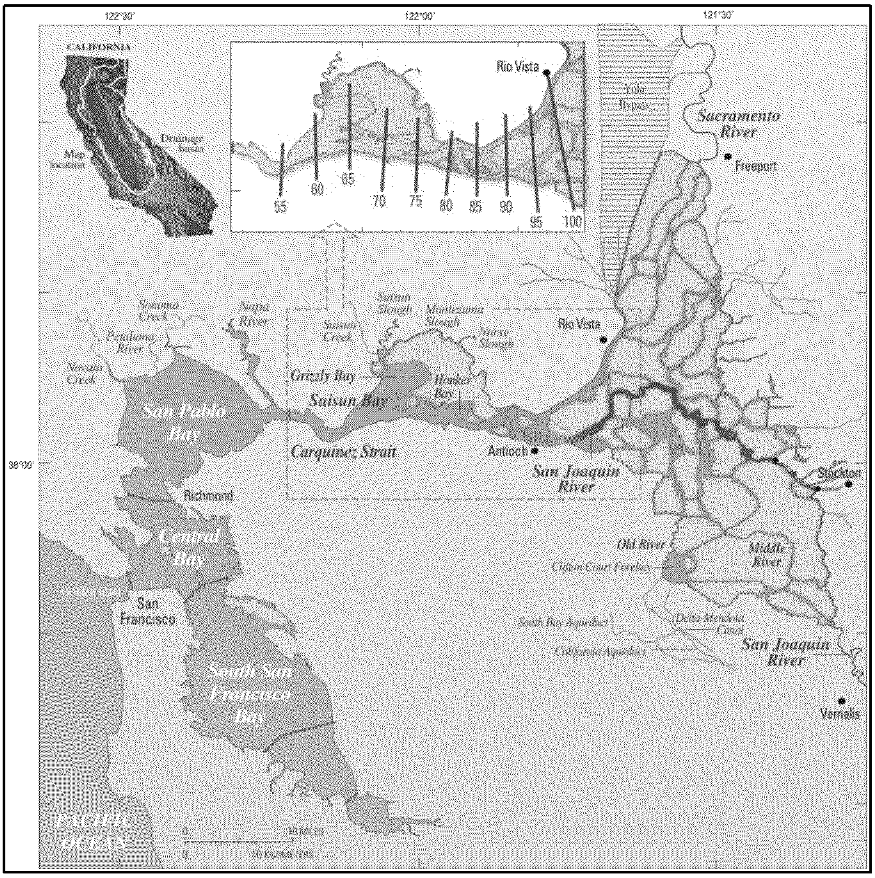
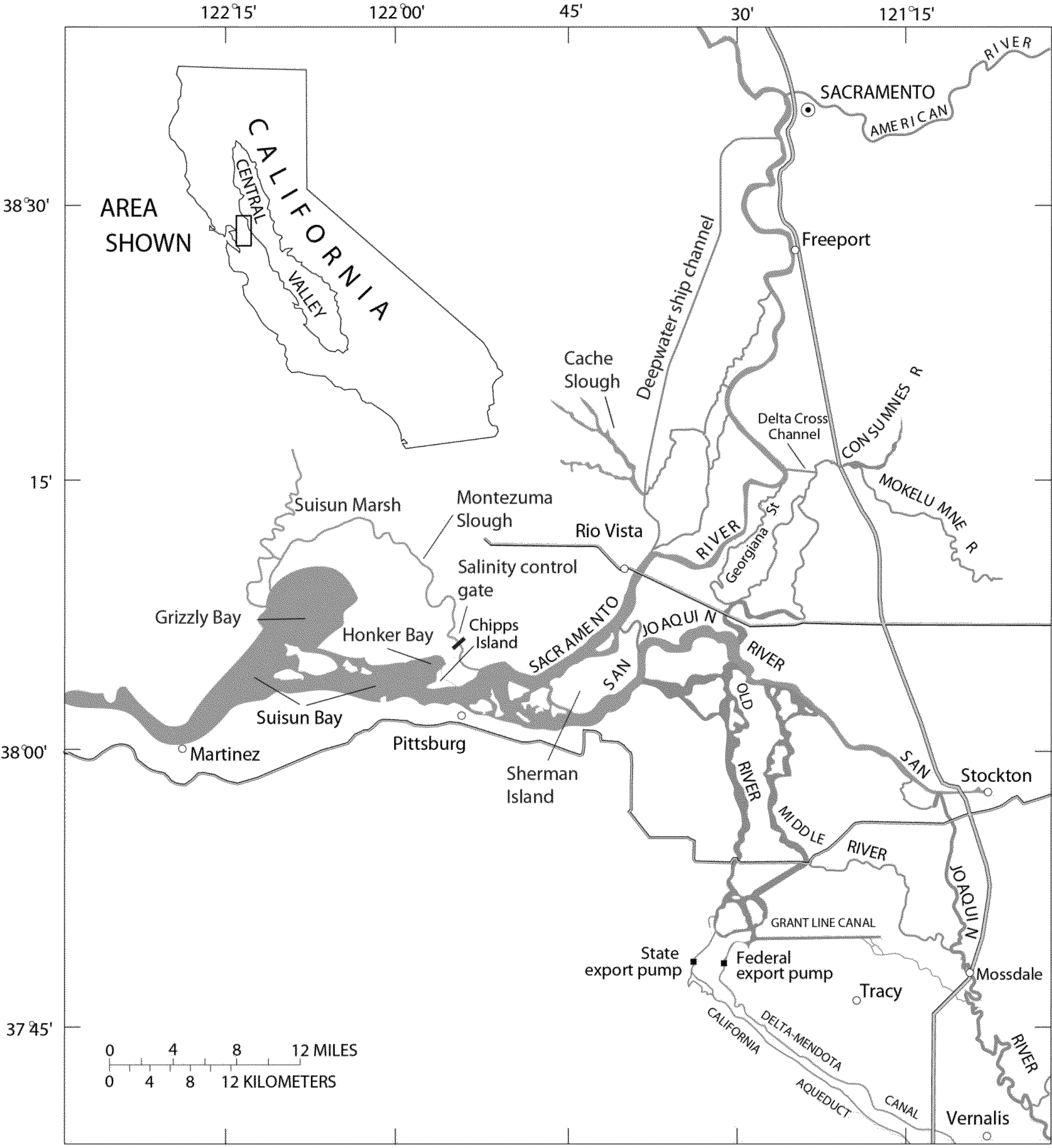


Figure 2. Map of the San Francisco Estuary. Also shown are isohaline positions (X2) measured at nominal distances (in kilometers) from the Golden Gate Bridge along the axis of the estuary (adapted from Jassby et al. (1995)).

Figure 3. Map of the Sacramento-San Joaquin Delta, Suisun Bay and associated areas.



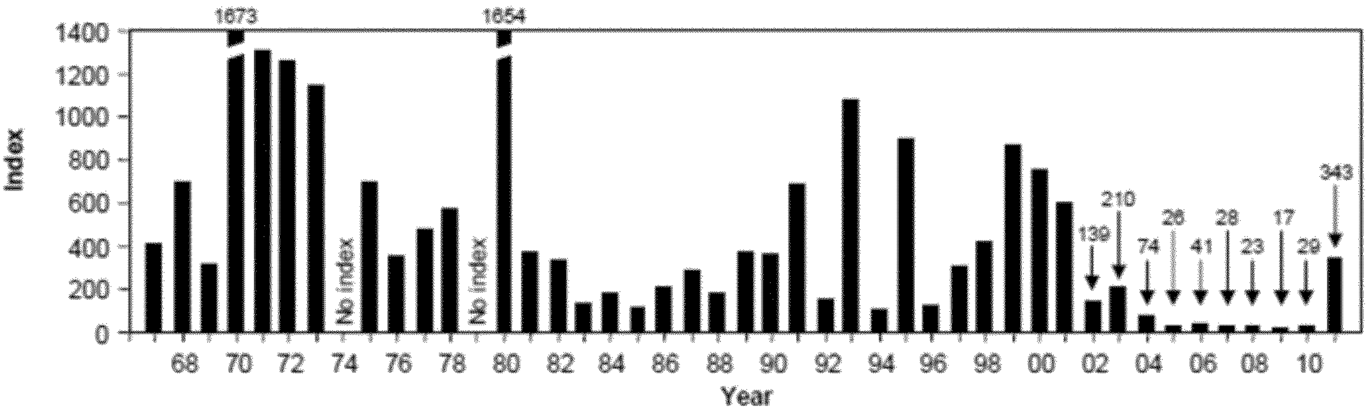


Figure 4. Delta smelt abundance index from the fall midwater trawl survey. The survey was not conducted in 1974 or 1979.

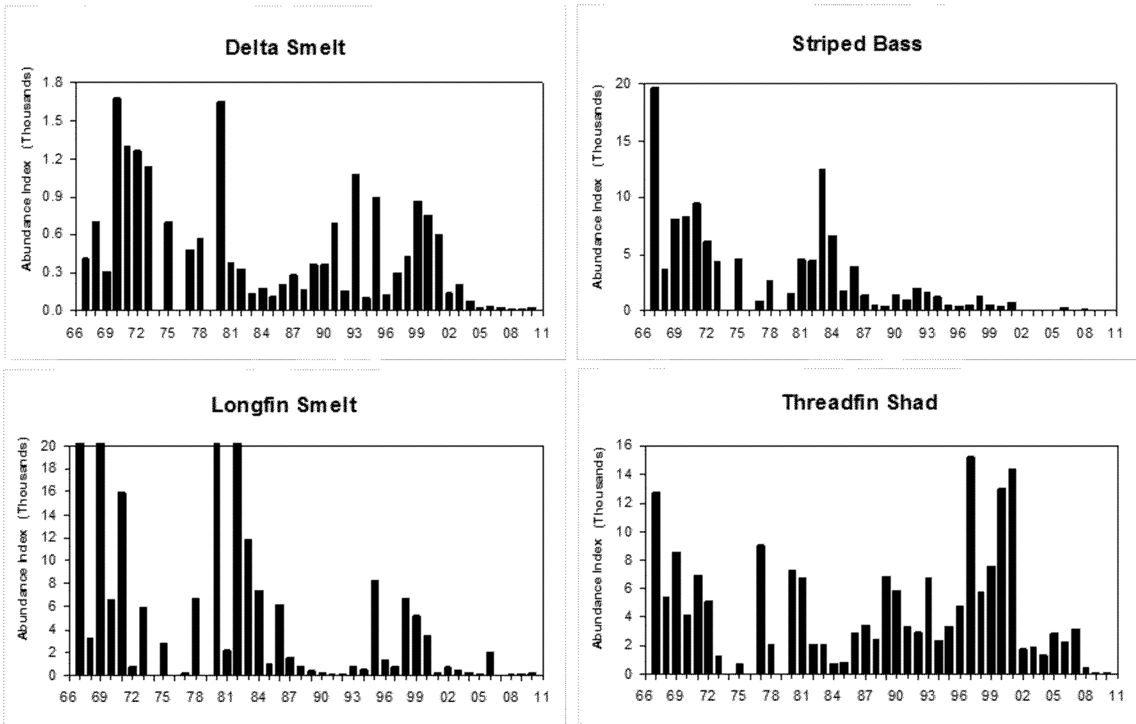


Figure 5. Trends in abundance indices for four pelagic fishes from 1967 to 2010 based on the Fall Midwater Trawl, a California Department of Fish and Game survey that samples the upper San Francisco Estuary. No sampling occurred in 1974 or 1979 and no index was calculated for 1976. Note that the y-axis for longfin smelt represents only the lower 25% of its abundance range to more clearly portray the lower abundance range.

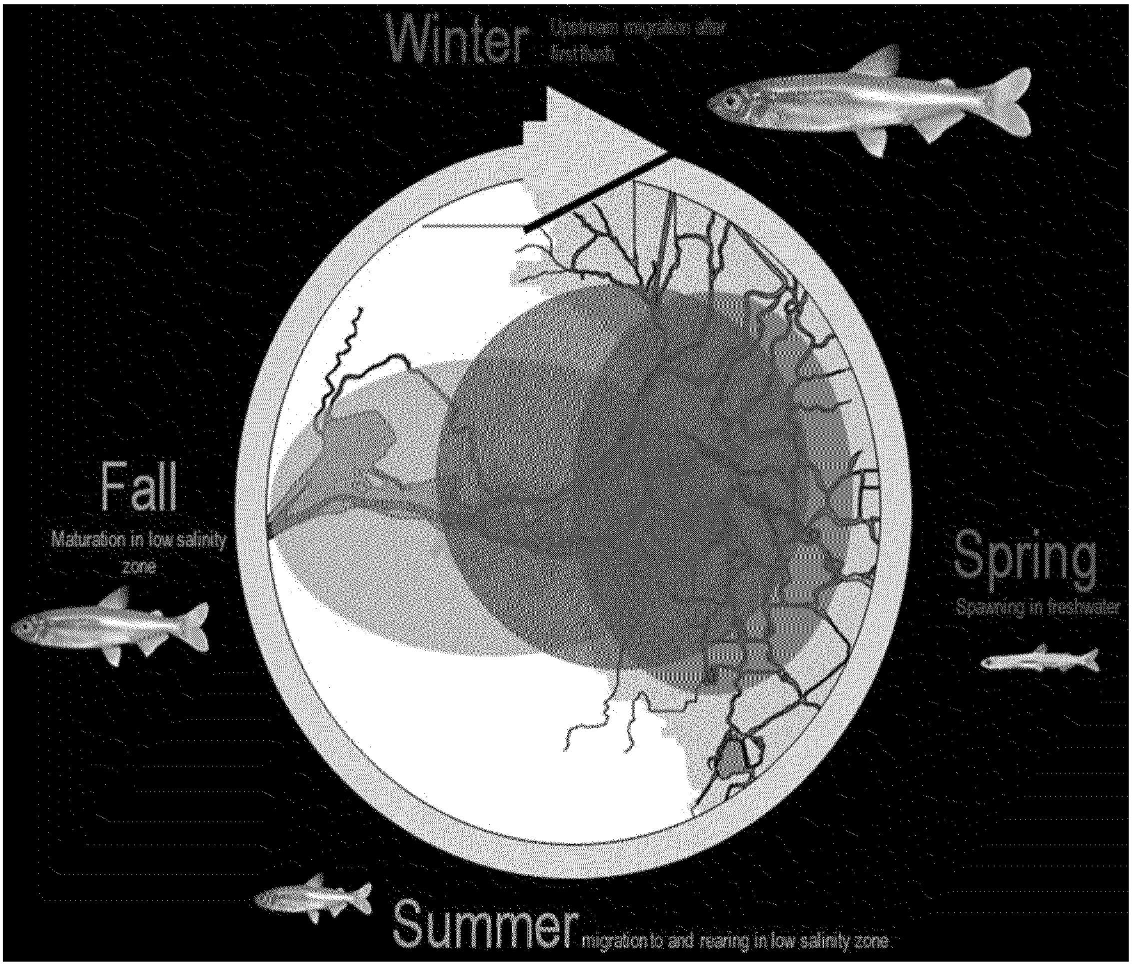


Figure 6. Simple conceptual diagram of the delta smelt annual life cycle (modified from Bennett 2005).

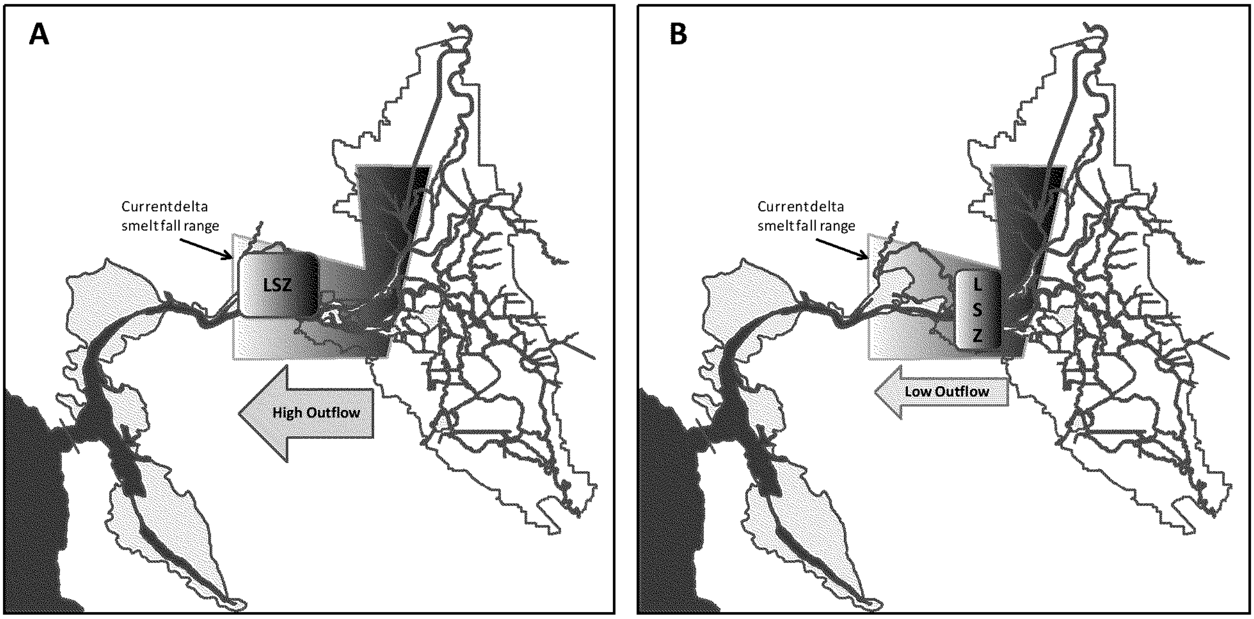


Figure 7. In the fall, delta smelt are currently found in a small geographic range (yellow shading) that includes the Suisun region, the river confluence, and the northern Delta, but most are found in or near the LSZ. **A:** The LSZ overlaps the Suisun region under high outflow conditions. **B:** The LSZ overlaps the river confluence under low outflow conditions (from Reclamation 2011).

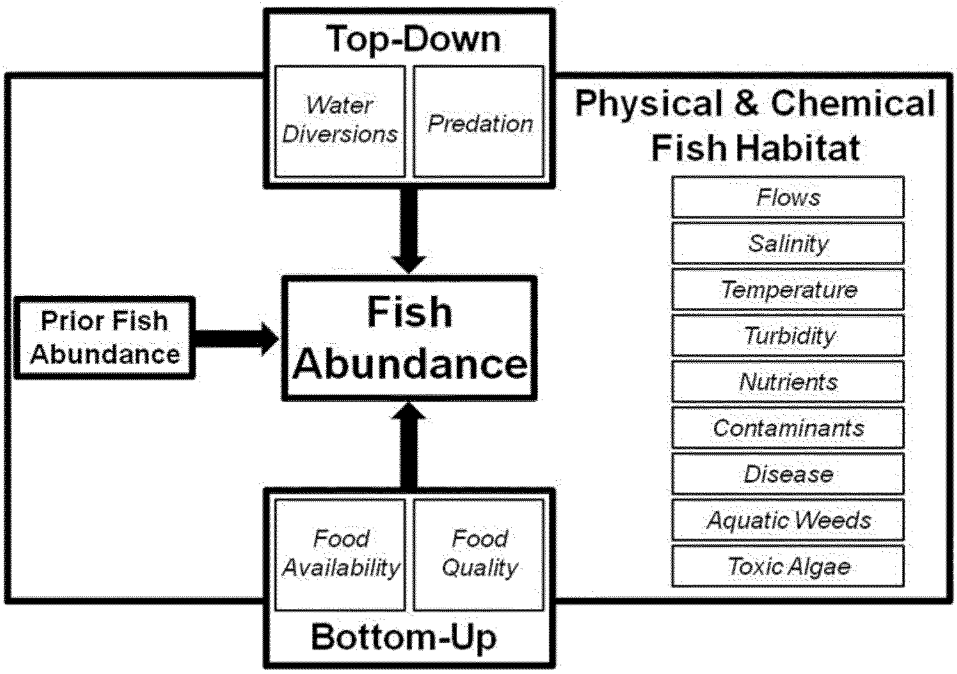


Figure 8. The basic conceptual model for the pelagic organism decline (adapted from Baxter and others 2010).

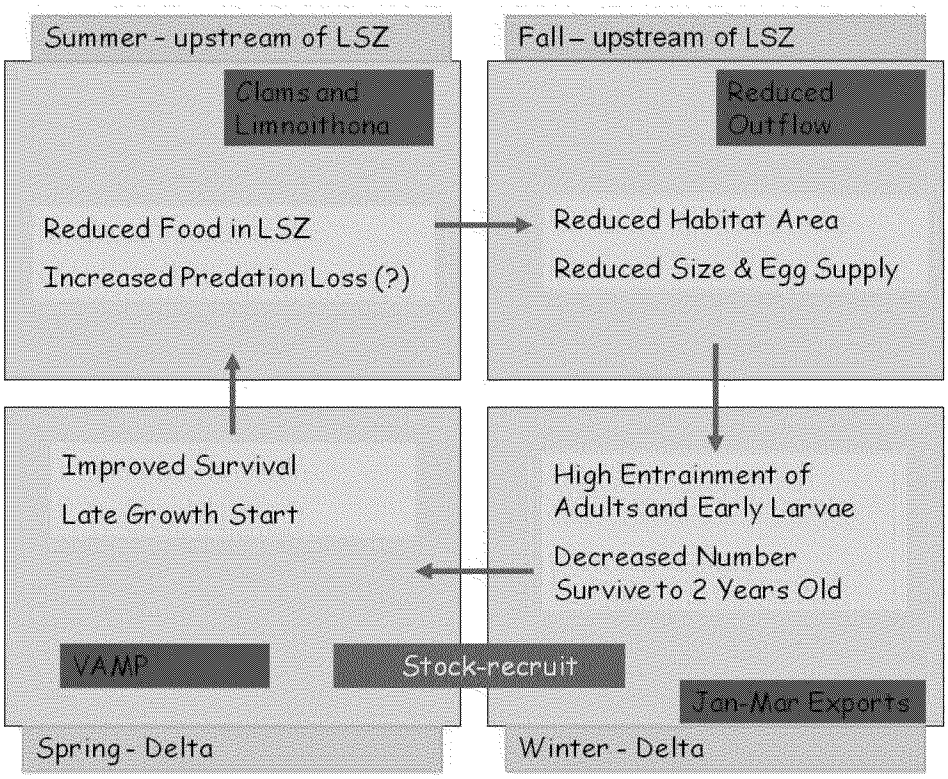


Figure 9. Delta smelt species-specific model (adapted from Baxter and others, 2010)

Old Regime	Environmental Drivers	New Regime
Variable, High	Outflow	*Variable, Lower*
To the west, Variable	Salinity gradient	*To the east, Constricted*
Complex, Variable	Landscape	*Simplified, Rigid*
Low, Variable	Temperature	*High, Uniform*
High, Variable	Turbidity	*Low, Less variable*
High P, low N	Nutrients	*Low P, High N (NH_4+)*
Few, Low	Contaminants	*Many, High*
Predation, Fishing	"Harvest"	*Predation and Entrainment*

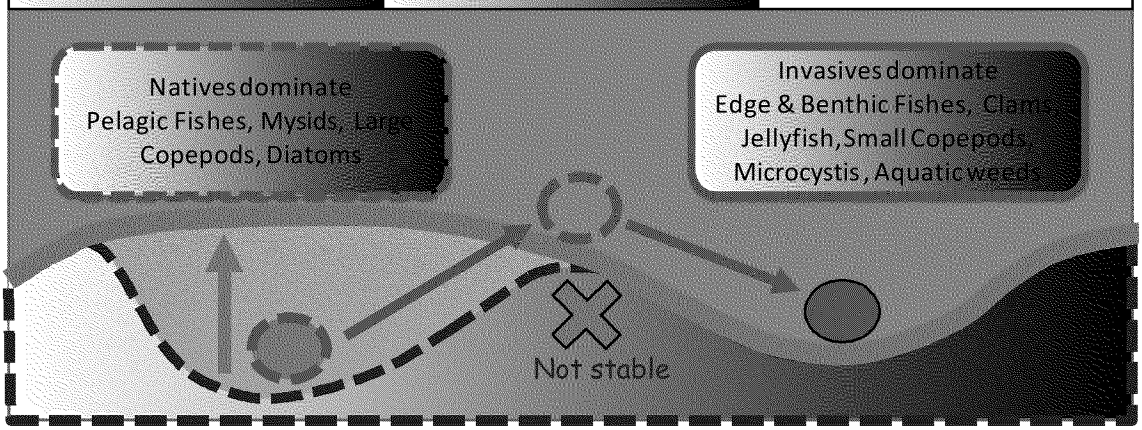


Figure 10. Regime shift model from Baxter and others (2010). The model assumes that ecological regime shift in the Delta results from changes in (slow) environmental drivers (top panel) that lead to profoundly altered biological communities (bottom panel). Introduction of invasive species is also an important process in producing the shift. The ecosystem must pass through an unstable threshold region before the new relatively stable ecosystem regime is established.

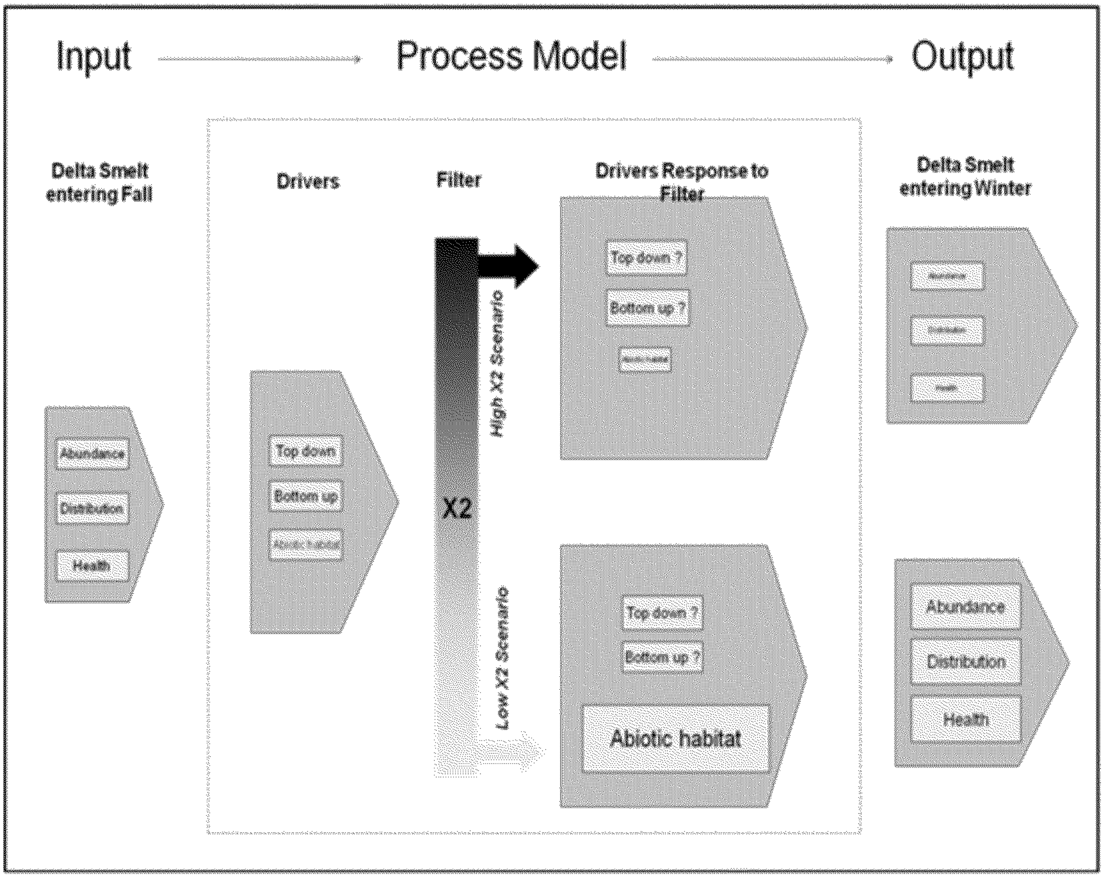


Figure 11. Habitat Study Group model of effects of fall low salinity habitat position and indexed by X2 on delta smelt through changes in habitat quantity and quality. Position and extent of fall low salinity habitat affects (either directly or indirectly) the expected outcomes for the same drivers (from Reclamation 2011).

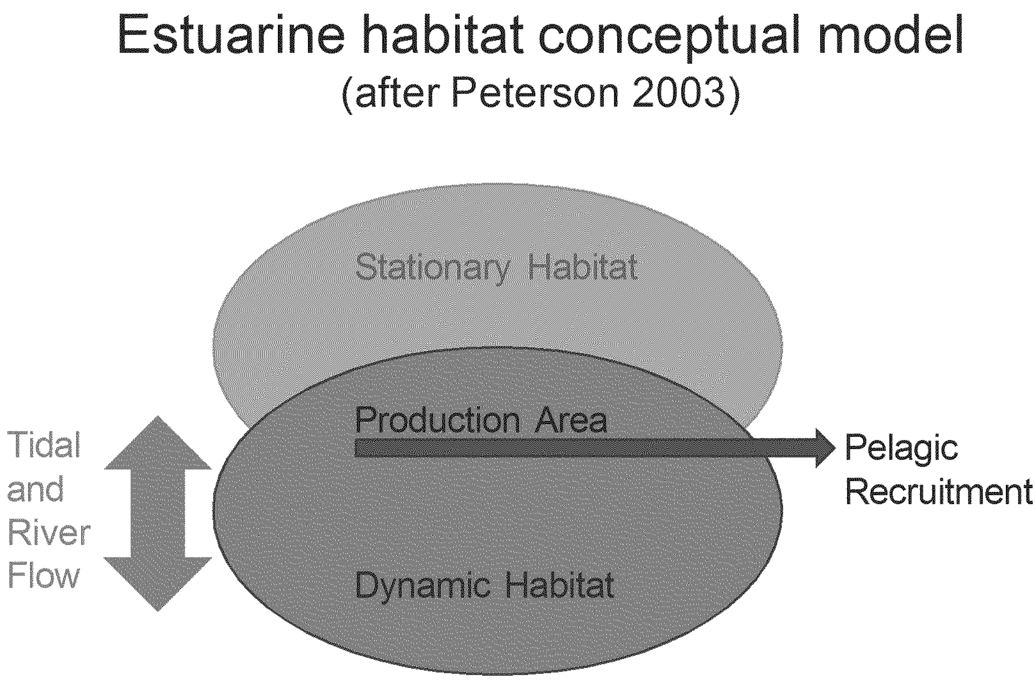


Figure 12. Estuarine habitat conceptual model (after Peterson 2003)).

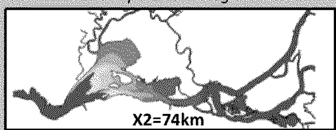
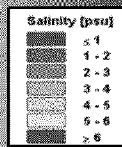
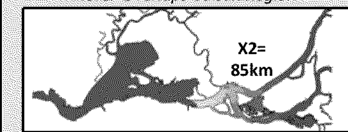
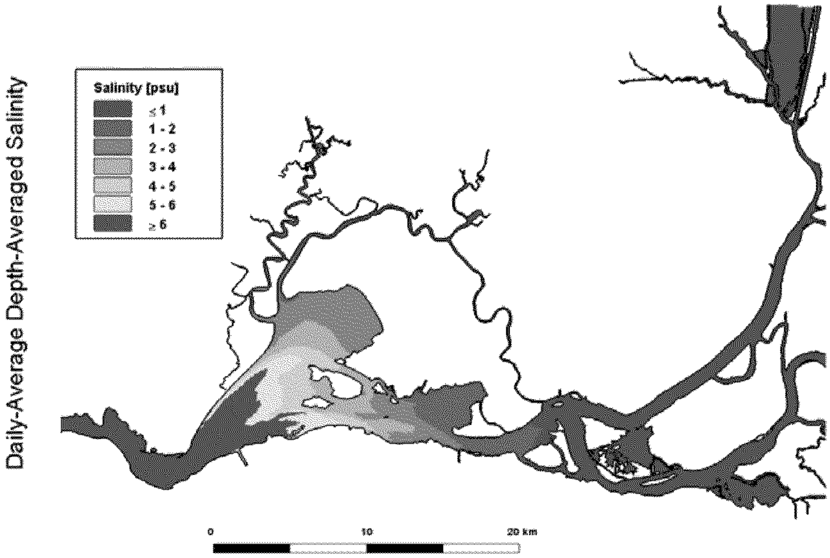
Suisun Region	Stationary Abiotic Habitat Components	River Confluence
Higher	Bathymetric Complexity	*Lower*
Higher	Erodible Sediment Supply	*Lower*
Many in South, Fewer in North	Contaminant Sources	*Many*
Fewer	Entrainment Sites	*More*
Variable Fall Outflow Regime	**Dynamic Abiotic Habitat Components**	***Static Fall Outflow Regime***
Higher After Wet Springs	Net Total Delta Fall Outflow	*Always Low*
Higher After Wet Springs	San Joaquin River Contribution to Fall Outflow	*Always Low*
After Wet Springs, Broad Fall LSZ Overlaps Suisun Region 	Location and Extent of the Fall LSZ (1-6 psu) 	*Narrow Fall LSZ In River Channels, Never Overlaps Suisun Region* 
Higher After Wet Springs	Hydrodynamic Complexity in the Fall LSZ	*Always Lower*
Higher After Wet Springs	Wind speed in the Fall LSZ	*Always Lower*
More Variable, Higher After Wet Springs	Turbidity in the Fall LSZ	*Always Less Variable, Lower*
More Variable, Maybe Lower After Wet Springs	Contaminant Concentrations in the Fall LSZ	*Less Variable, Maybe Higher*
LSZ Overlaps Suisun Region	**Dynamic Biotic Habitat Components**	***LSZ Overlaps River Confluence***
Higher	Food Availability and Quality	*Lower*
Variable	Predator Abundance	*Higher*
LSZ Overlaps Suisun Region	**Delta Smelt Responses**	***LSZ Overlaps River Confluence***
Broad, Westward	Distribution	*Constricted, Eastward*
Higher	Growth, Survival, Fecundity	*Lower*
Better	Health and Condition	*Worse*
May be Higher	Recruitment in the next Spring	*Lower*

Figure 13. Spatially explicit conceptual model for the western reach of the modern delta smelt range in the fall: interacting stationary and dynamic habitat features drive delta smelt responses.



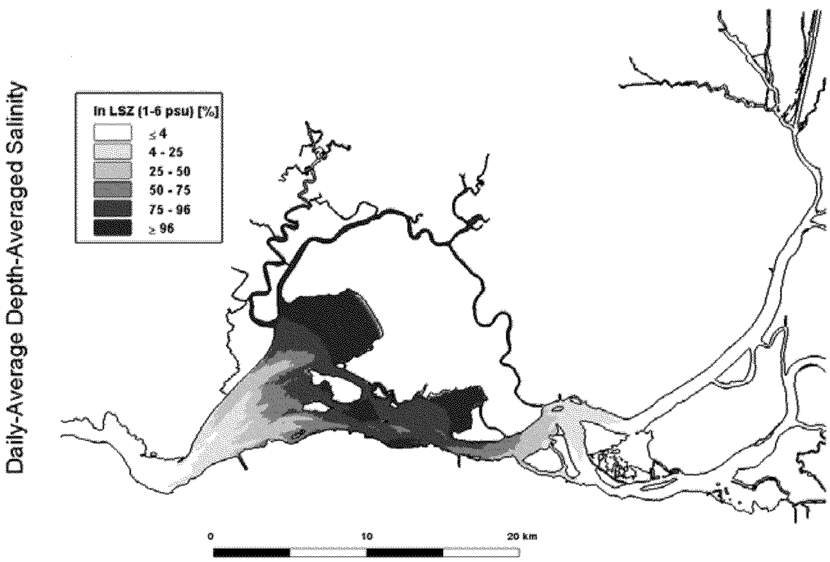


Figure 14. The upper panel shows the area of the LSZ (9,140 hectares) at X2 = 74 km (at Chipps Island). The lower panel shows the percentage of day that the LSZ occupies different areas.

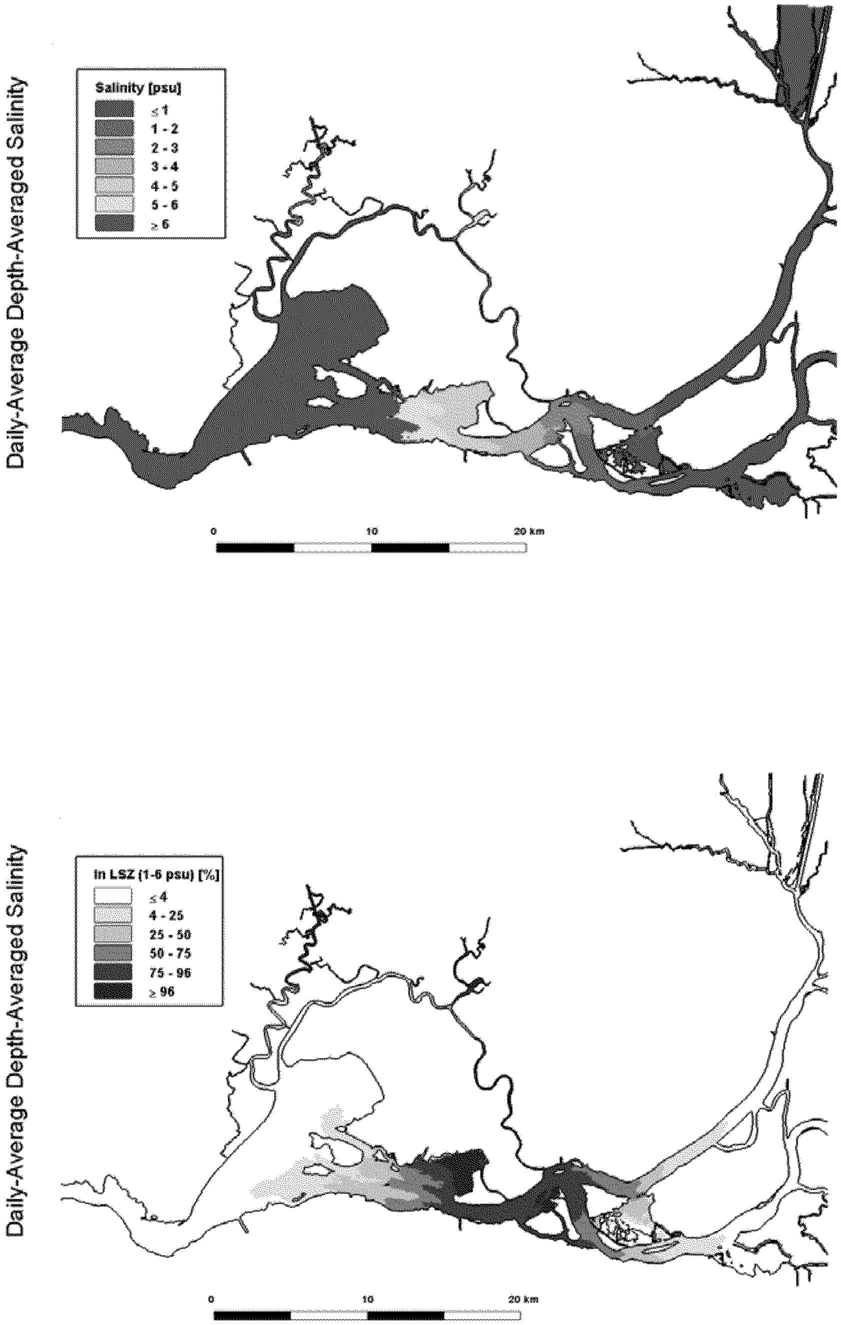
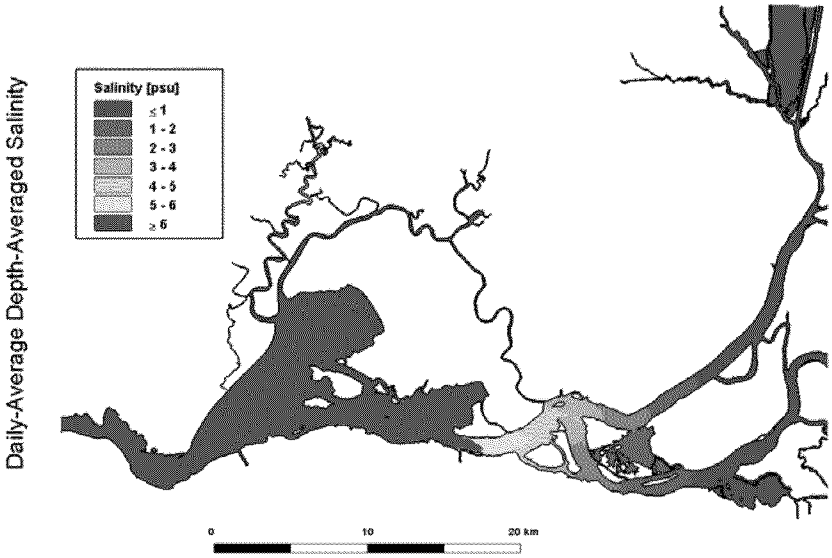


Figure 15. The upper panel shows the area of the LSZ (4,914 hectares) at X2 = 81 km (at the confluence of the Sacramento and San Joaquin rivers), when the LSZ is confined within the relatively deep channels of the western Delta. The lower figure shows percentage of day that the LSZ occupies different areas.



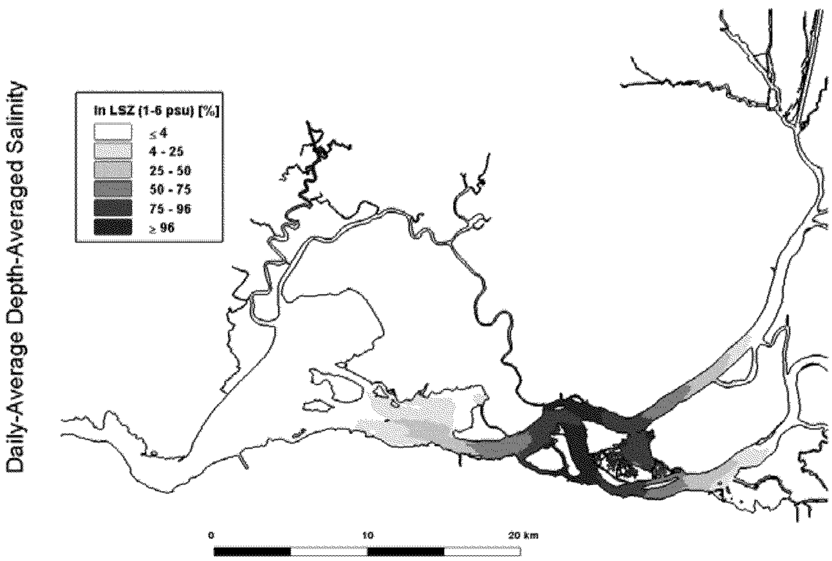


Figure 16. The upper panel shows the area of the LSZ (4,262 hectares) at X2 = 85 km, when positioned mostly between Antioch and Pittsburg. Connections to Suisun Bay and Marsh have nearly been lost. The lower panel shows the percentage of day that the LSZ occupies different areas.

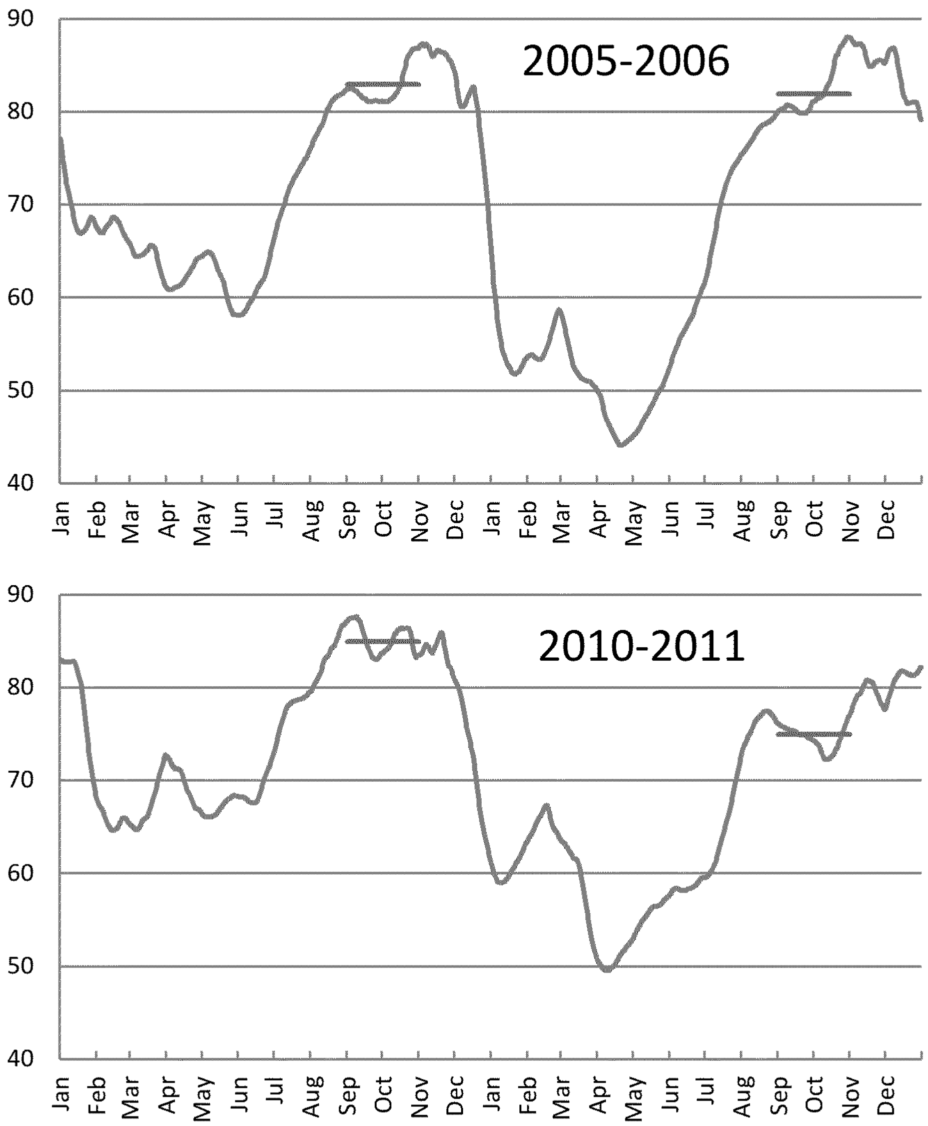


Figure 17. Daily X2 for 2005-2006 and 2010-2010. Mean daily X2 for each year during the September to October period is shown by the horizontal bar.

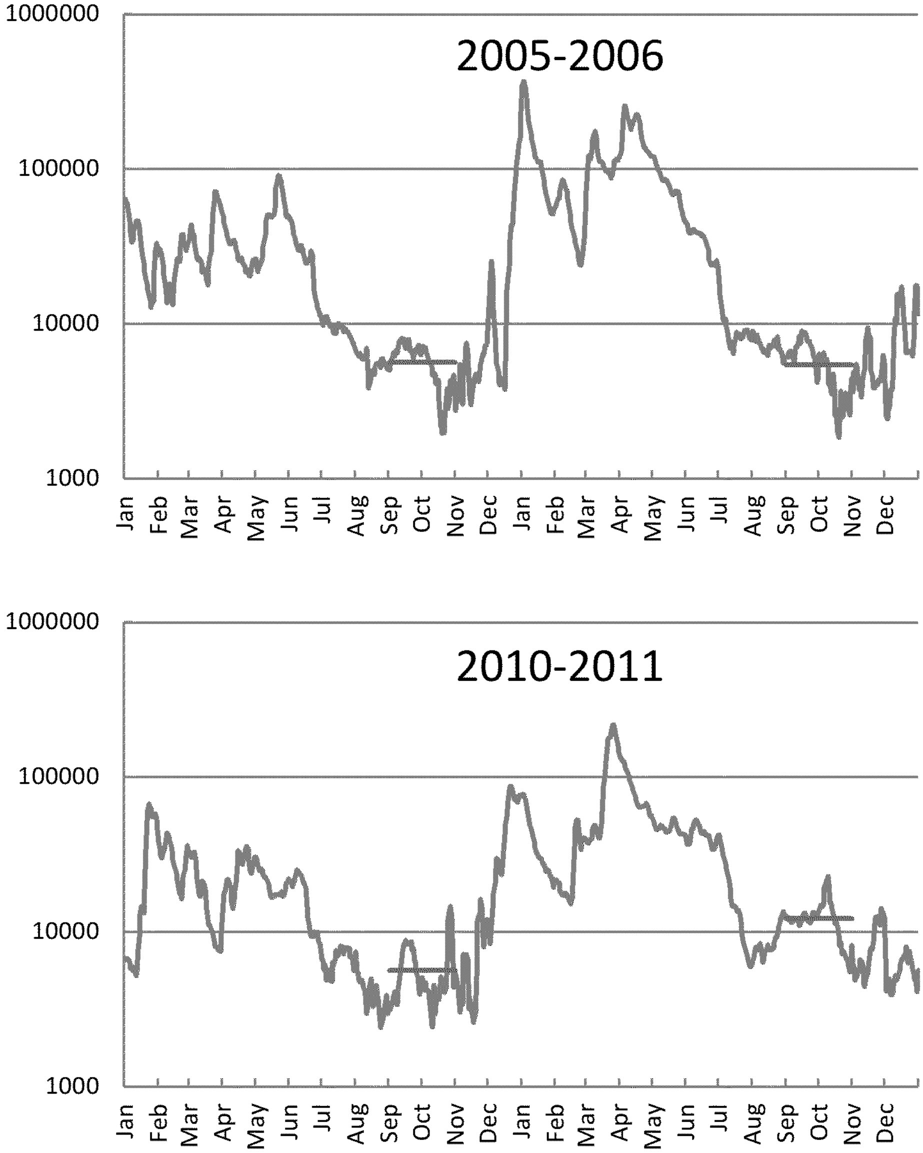


Figure 18. Daily Delta outflow (cfs) for 2005-2006 and 2010-2010. Mean daily ouflow during the September to October period are shown by the horizontal bar.

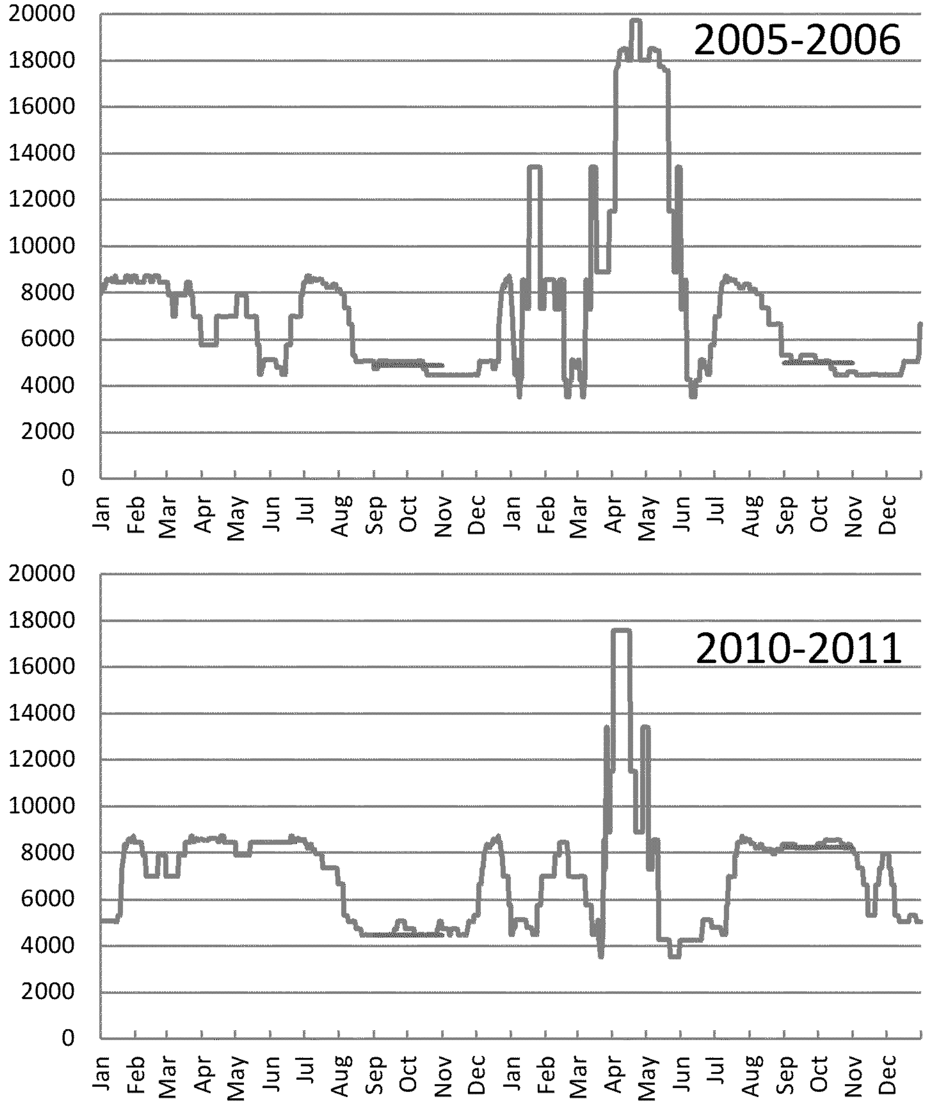


Figure 19. Daily area (hectares) of the depth averaged low salinity zone (salinity 1-6) for 2005-2006 and 2010-2010. Mean daily areas during the September to October period are shown by the horizontal bar.

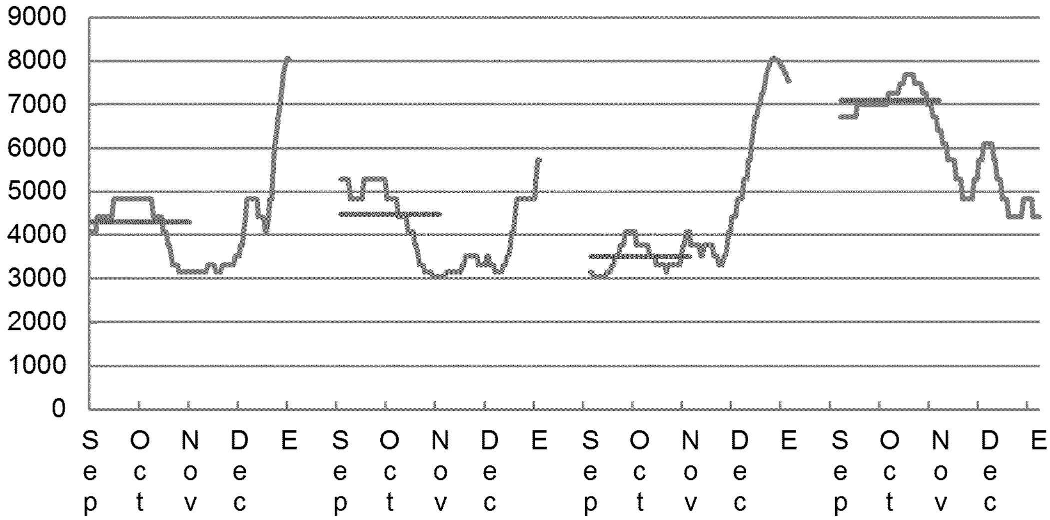
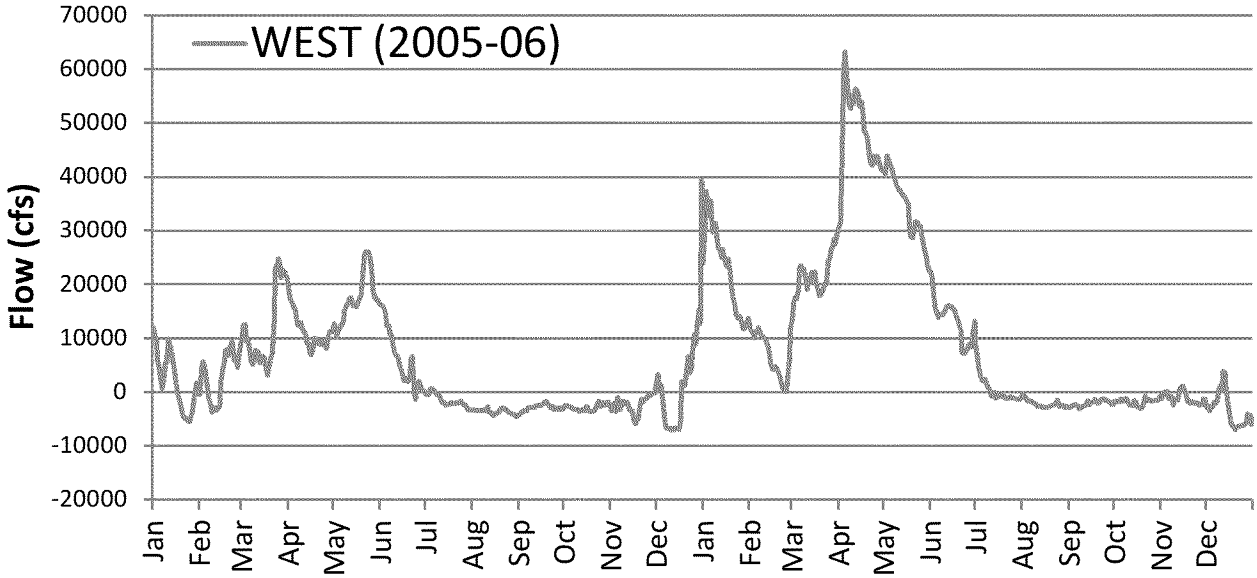


Figure 20. Daily delta smelt habitat index for the fall (Sep-Dec) for 2005, 2006, 2010, and 2011. Mean daily delta smelt habitat index during the September to October period are shown by the horizontal bar. The end of the data record each year is indicated by E.



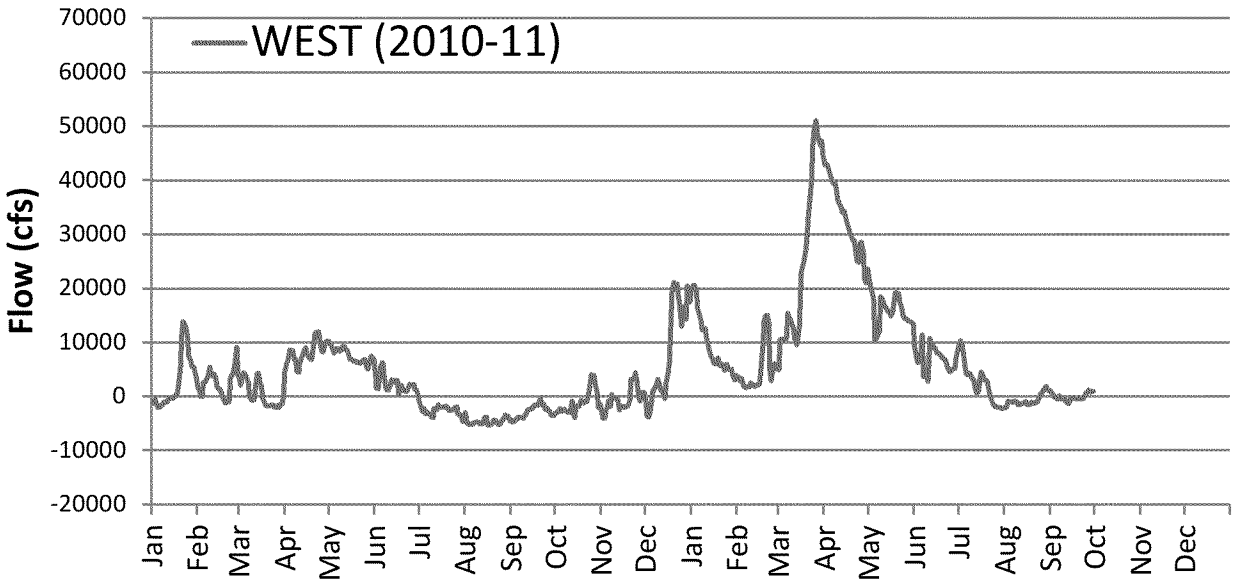


Figure 21. Daily net flow past Jersey Point on the San Joaquin River.

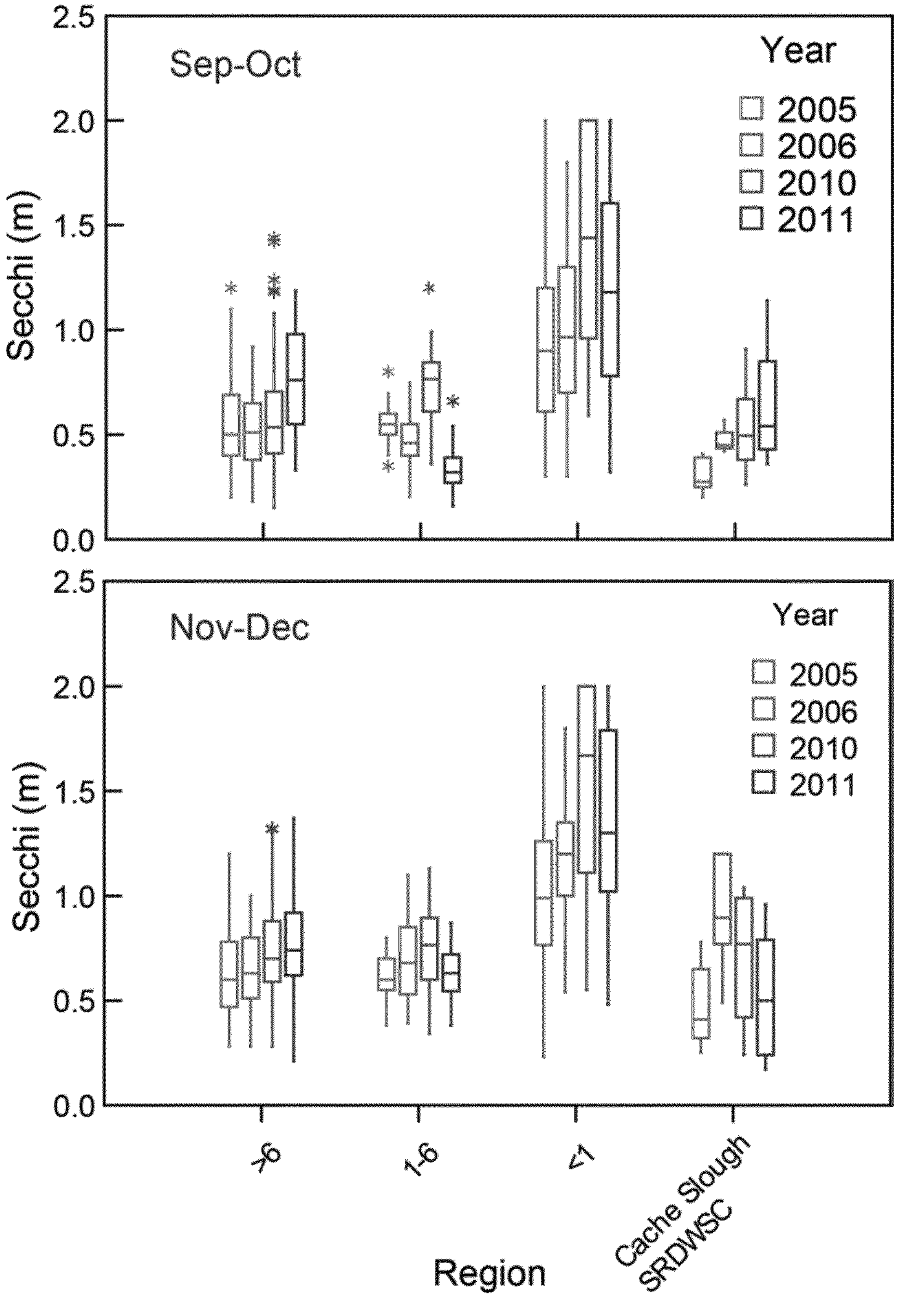


Figure 22. Secchi depth data collected during the FMWT fish sampling survey.

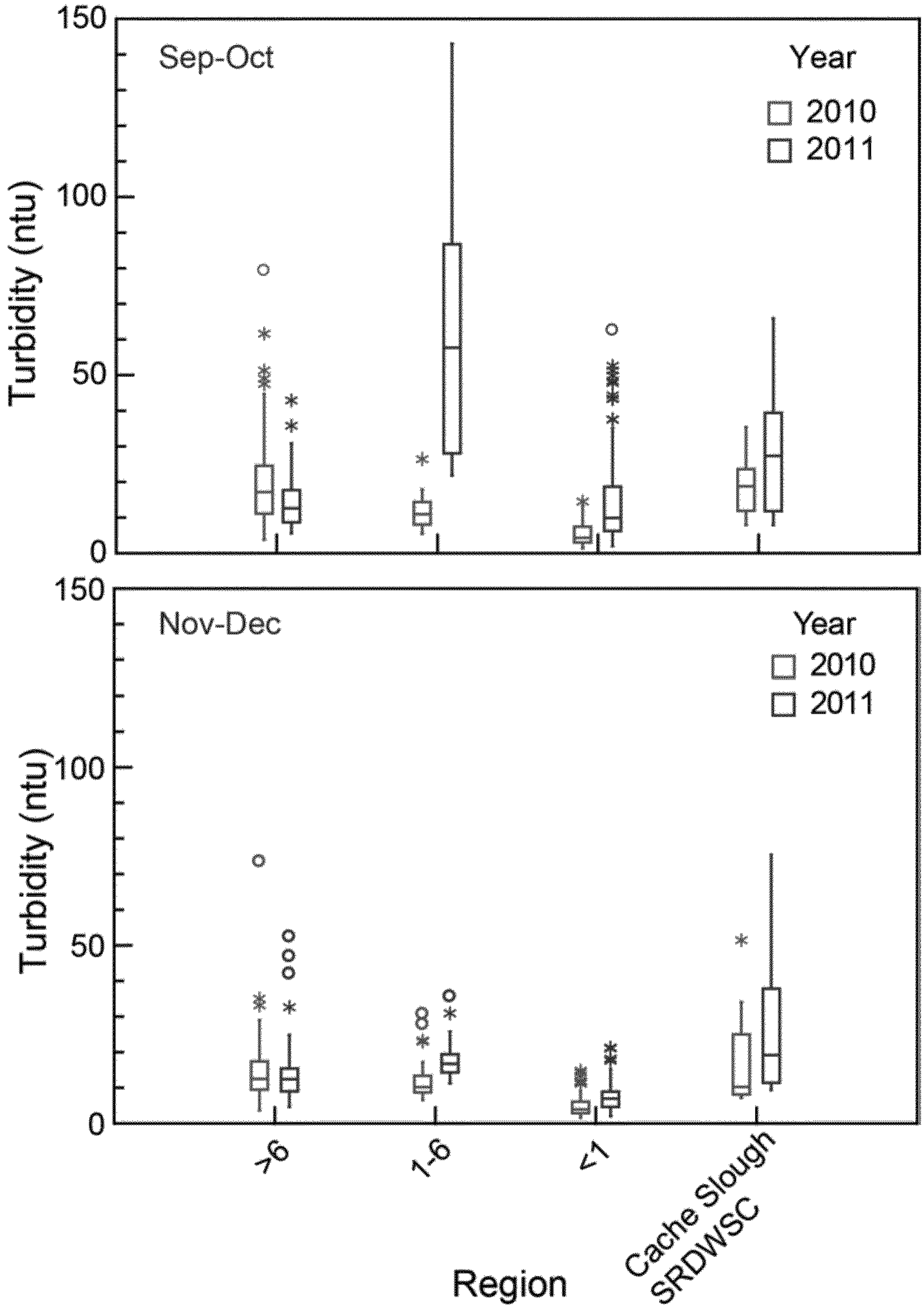


Figure 23. Turbidity data collected during the FMWT fish sampling survey. These data were not collected in 2005 and 2006.

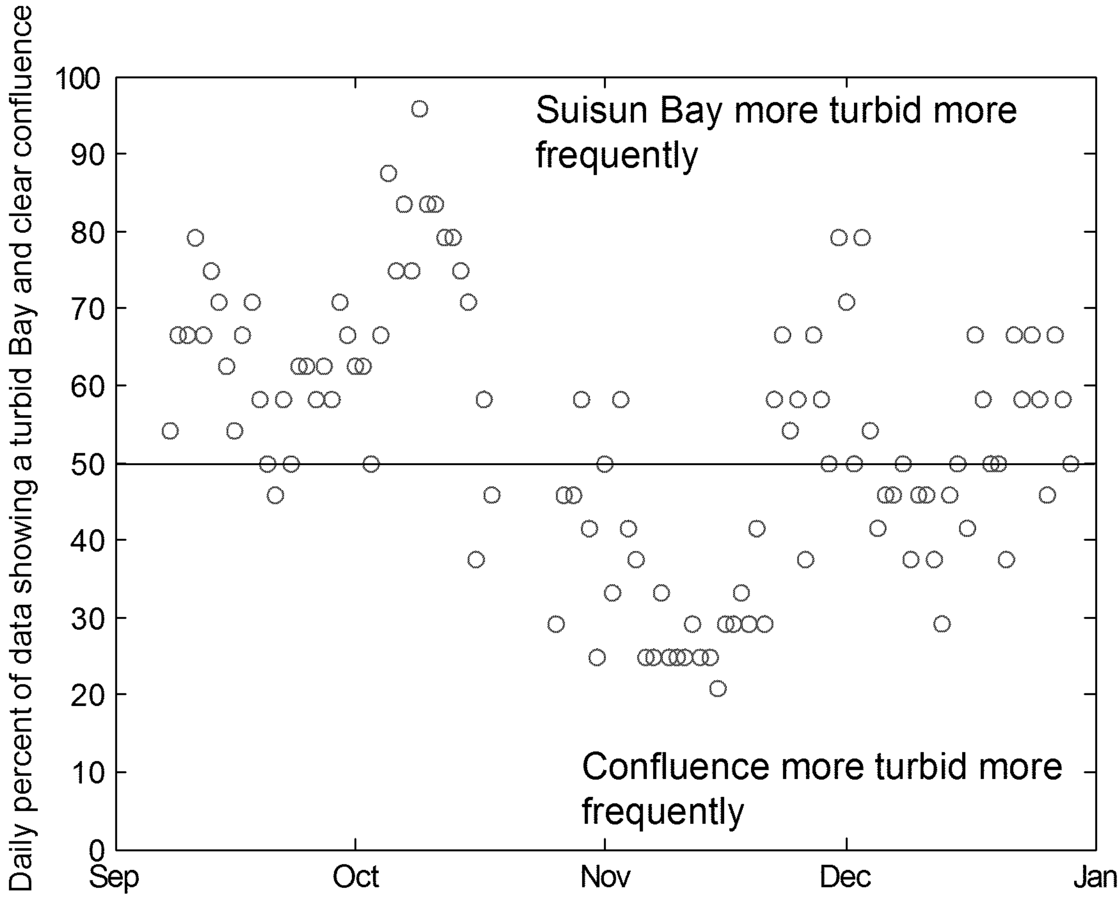


Figure 24. Percent of data showing a turbid Bay and clear confluence, September-December 2011. Calculated from the product of hourly deviations of specific conductance and suspended-sediment concentration from tidally-averaged values. Values greater than 50% indicate instantaneous salinity and SSC are either both positive (relatively turbid Bay water) or negative (relatively clear confluence water). Values less than 50% indicate that deviations of conductance and SSC have opposite signs (relatively clear Bay or relatively turbid confluence). See Appendix A.5 for details.

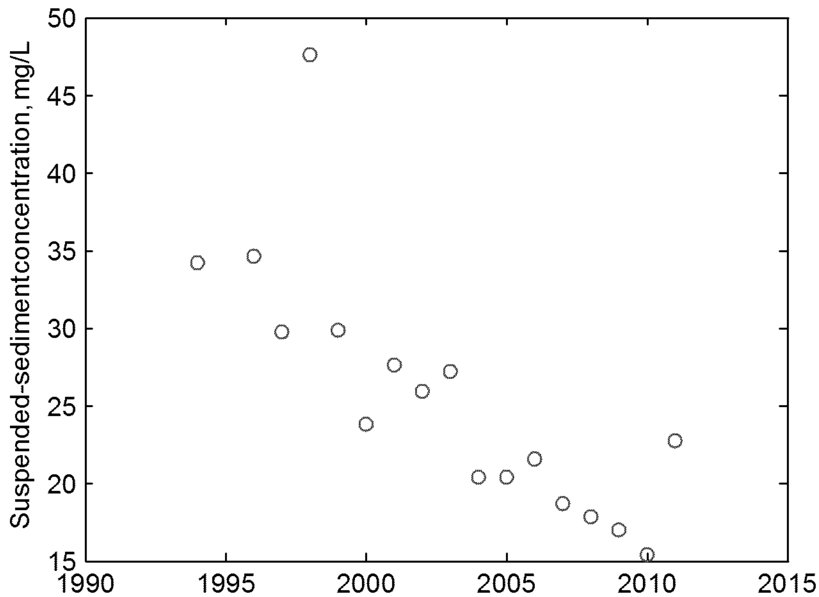


Figure 25. Near-surface suspended-sediment concentration at Mallard Island, September-October mean values, 1994-2011. 1995 is not included due to insufficient SSC data. See Appendix A.5 for more detail.

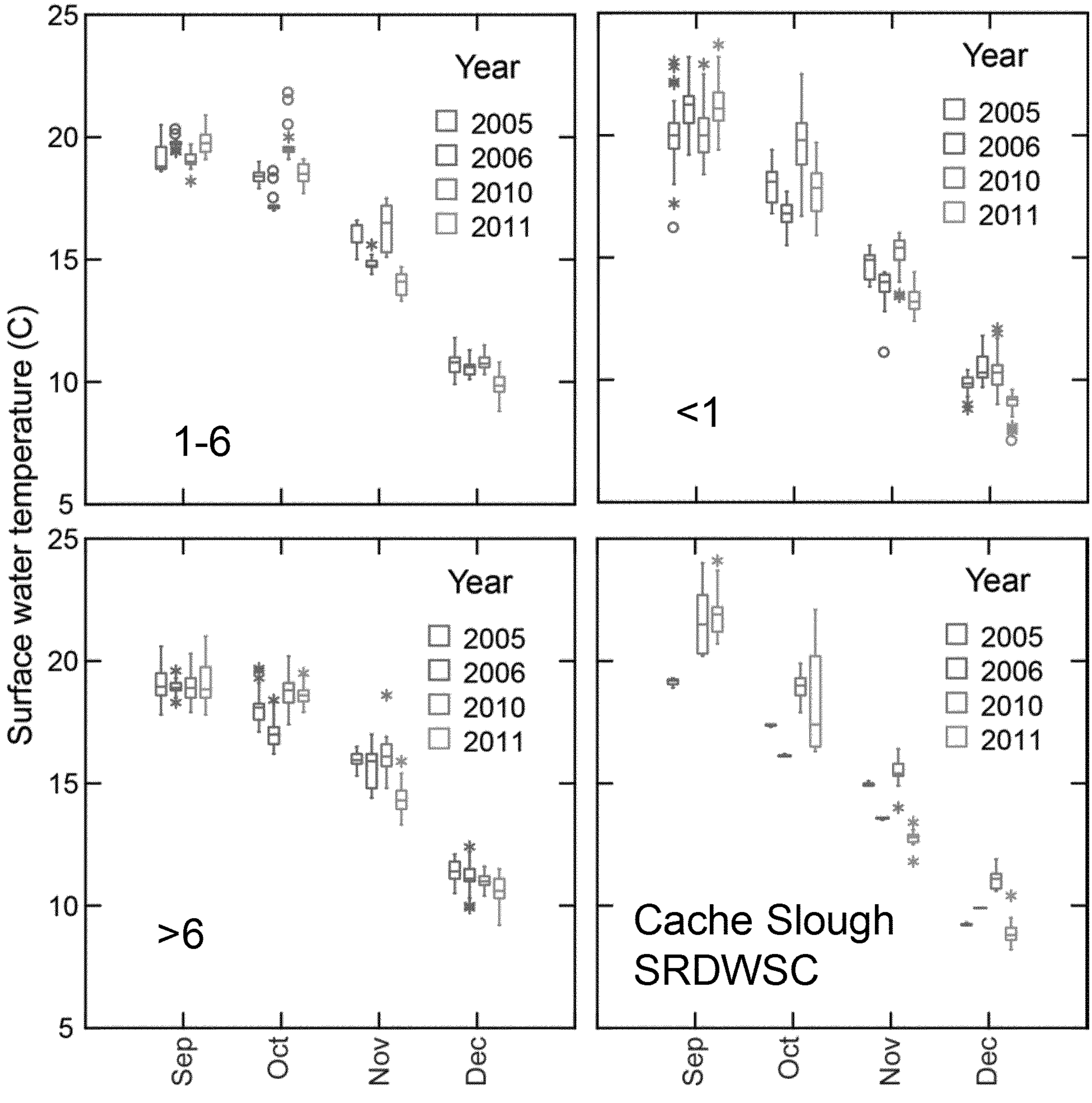


Figure 26. Surface water temperature (C) at FMWT sampling sites during monthly sampling.

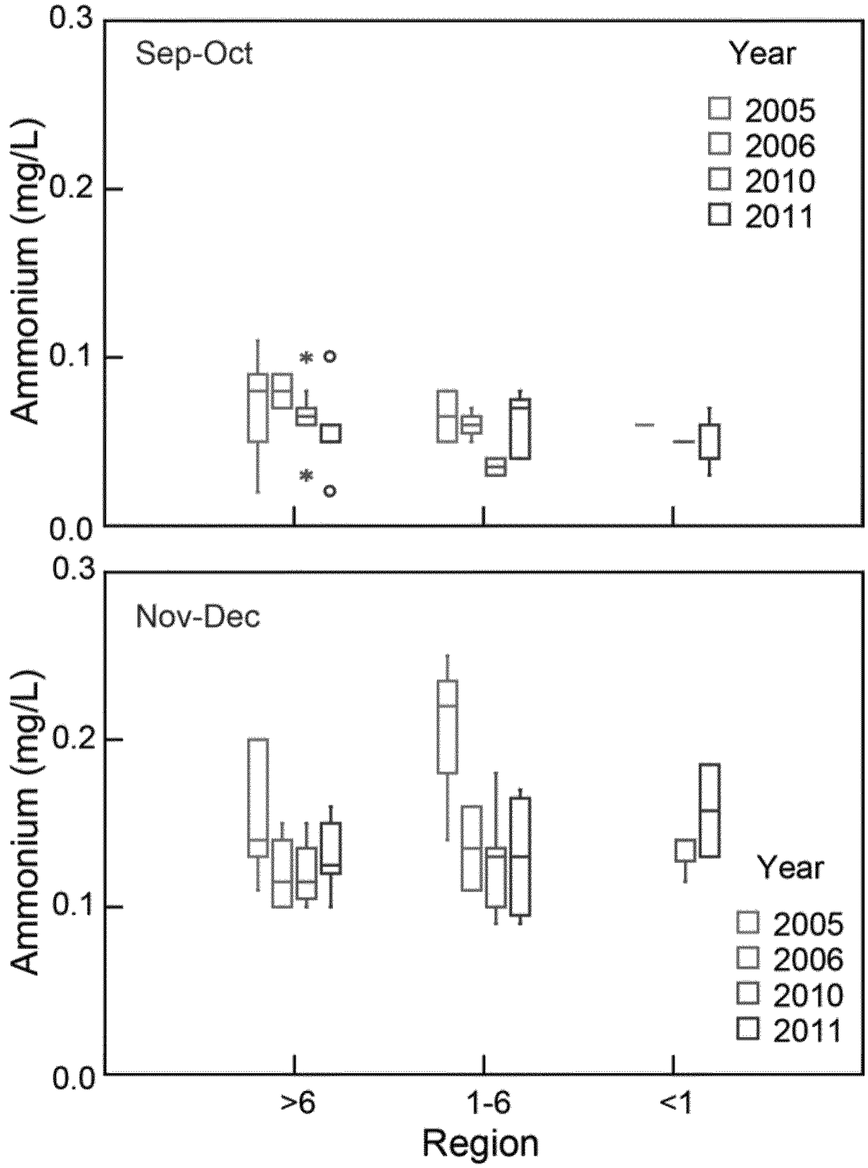


Figure 27. Ammonium concentrations in Sep-Oct and Nov-Dec from the IEP Environmental Monitoring Program (see Appendix A.6).

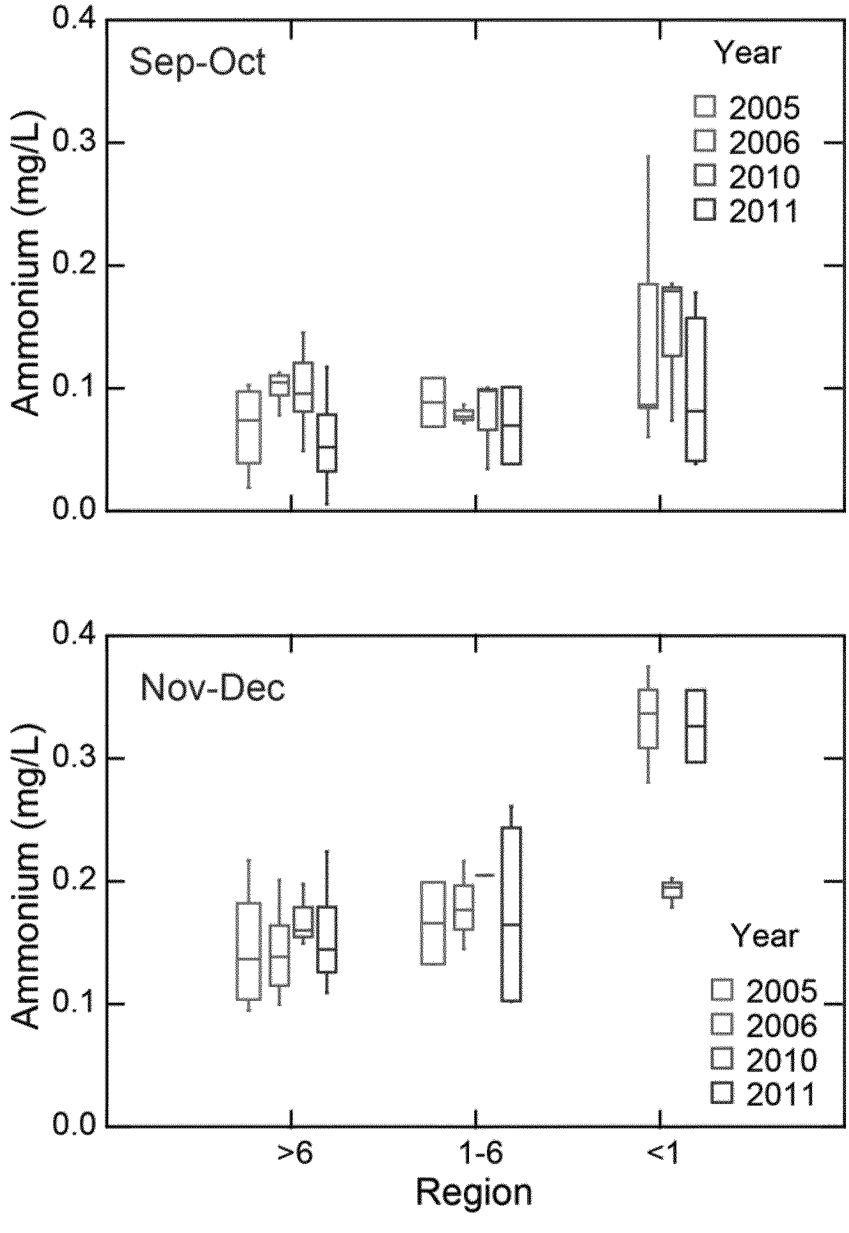


Figure 28. Ammonium data from USGS monthly sampling cruises.

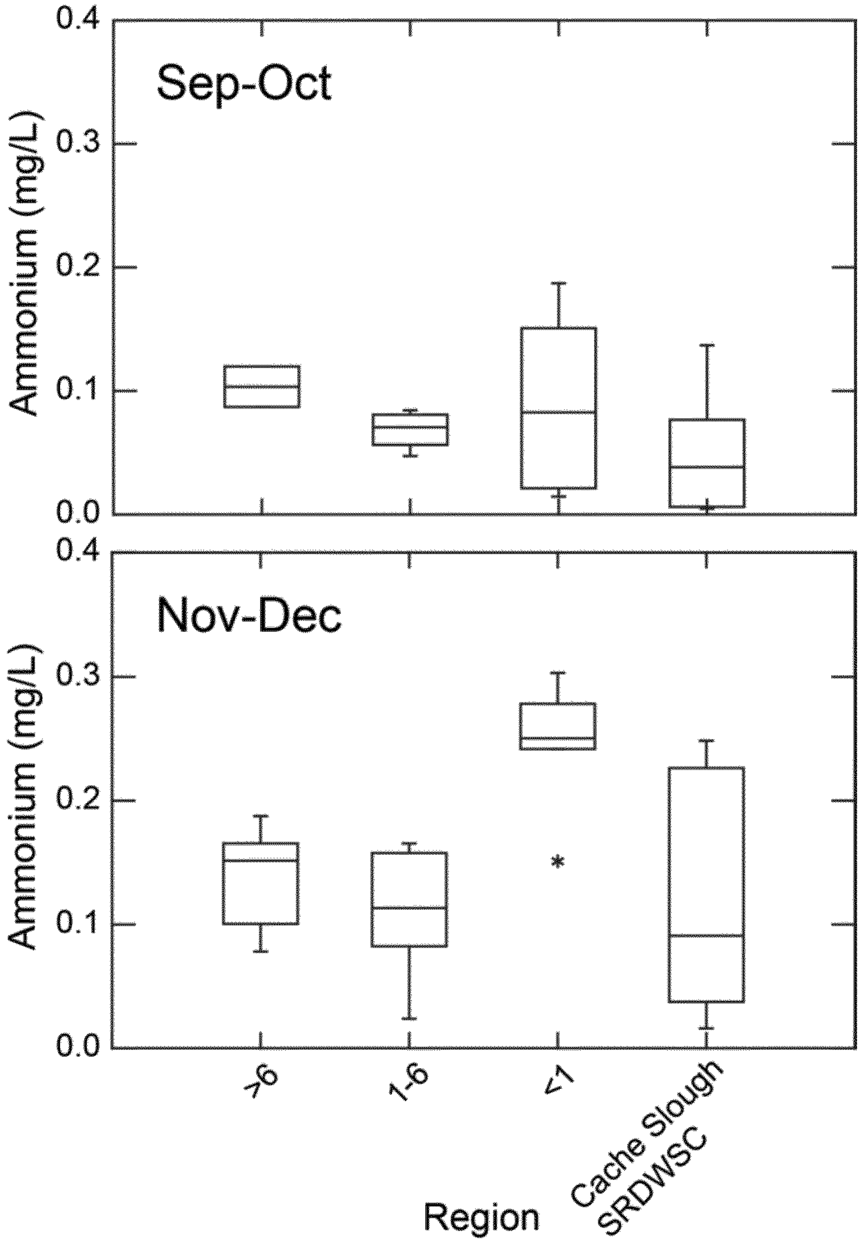


Figure 29. Ammonium concentrations in Sep-Oct and Nov-Dec 2011 from samples collected during the fall midwater trawl (see Appendix A.4).

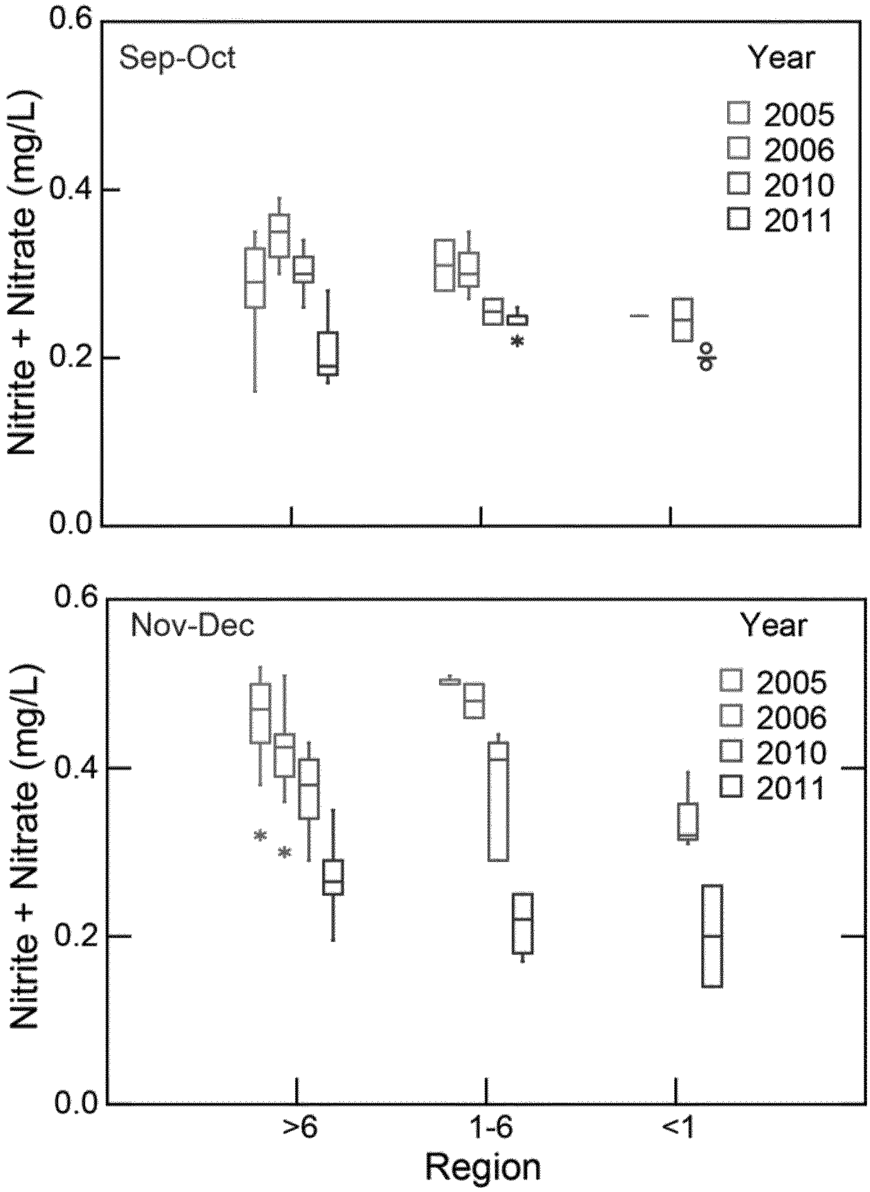


Figure 30. Nitrite + Nitrate concentrations in Sep-Oct and Nov-Dec from samples collected during EMP monitoring(see Appendix A.4).

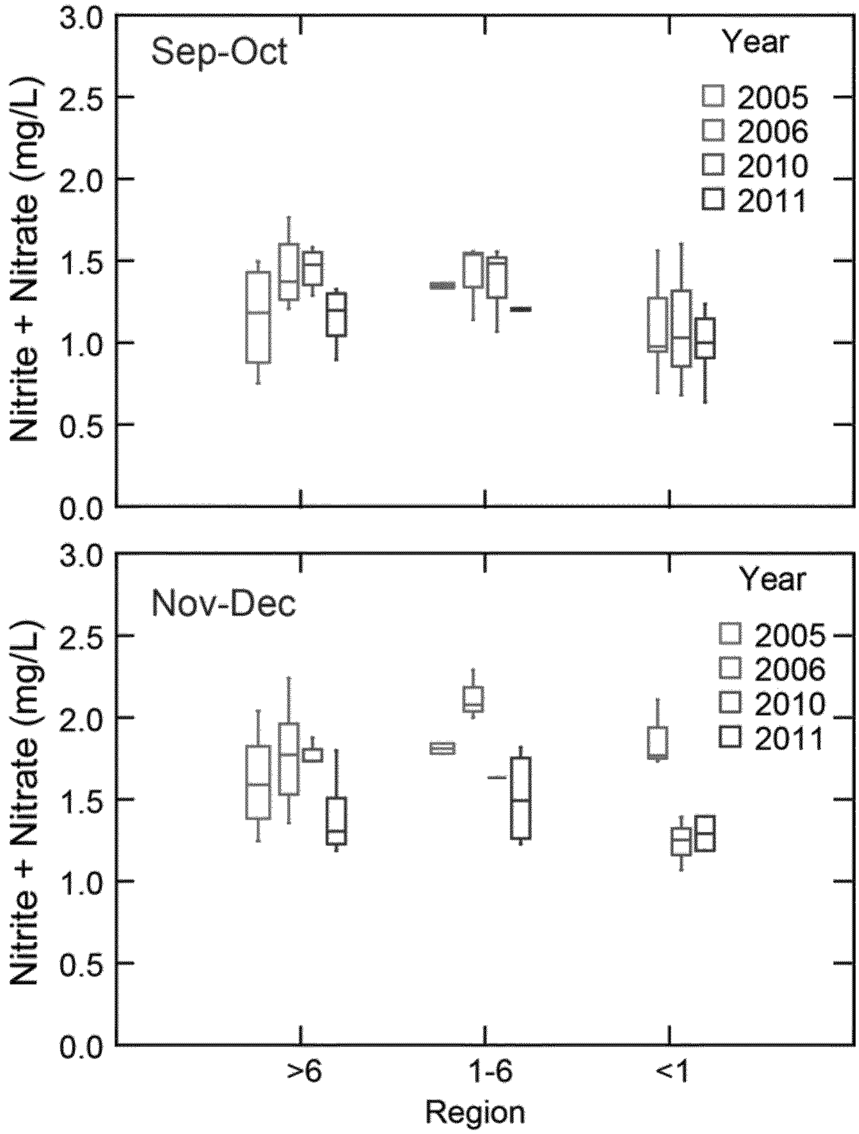


Figure 31. Nitrite + Nitrate concentrations in Sep-Oct and Nov-Dec 2011 from samples collected during monthly USGS cruises (see Appendix A.4). Original concentrations of nitrite + nitrate were measured in micromoles. Date wer converted to mg/L assuming 100% nitrate since nitrite concentrations were not yet available. This could result in concentrations biased slightly high.

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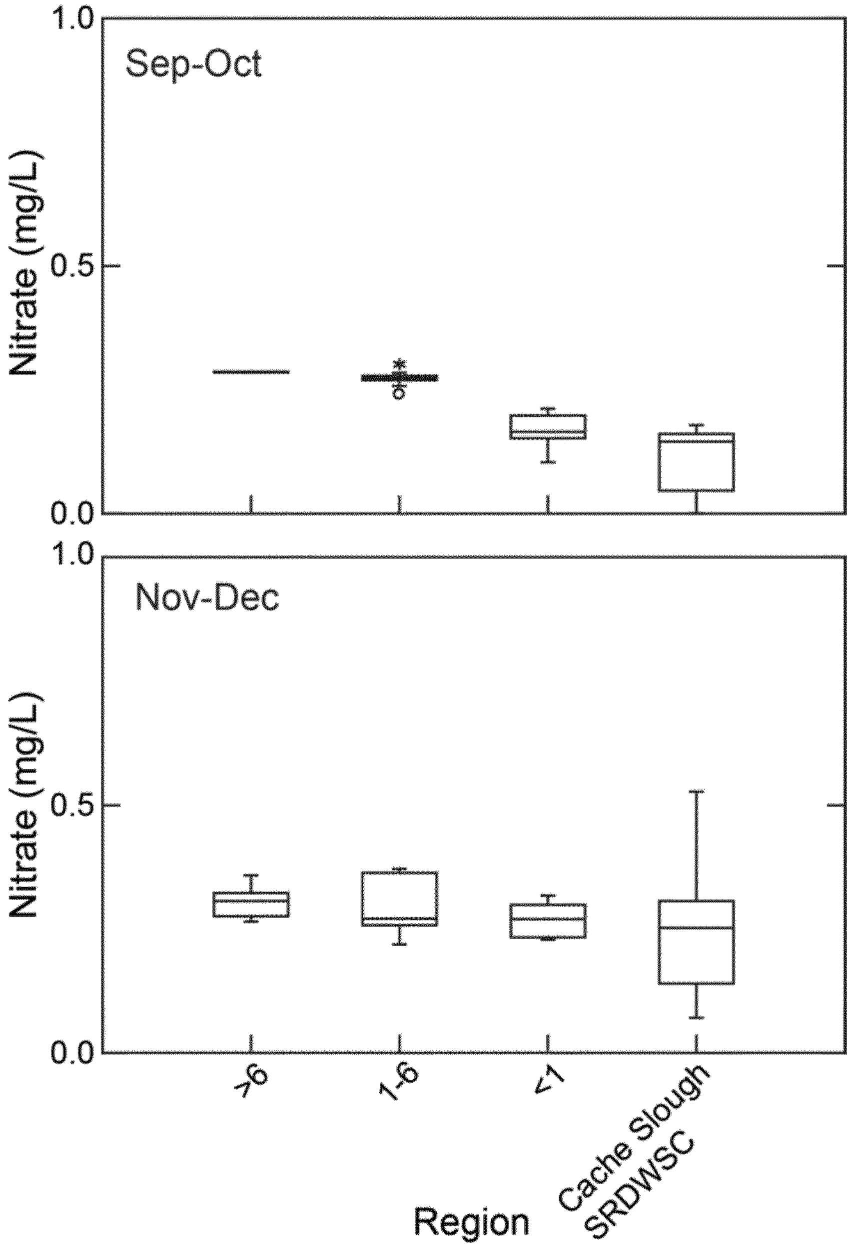

Figure 32. Nitrite + Nitrate concentrations in Sep-Oct and Nov-Dec 2011 from the samples collected during the fall midwater trawl (see Appendix A.4).

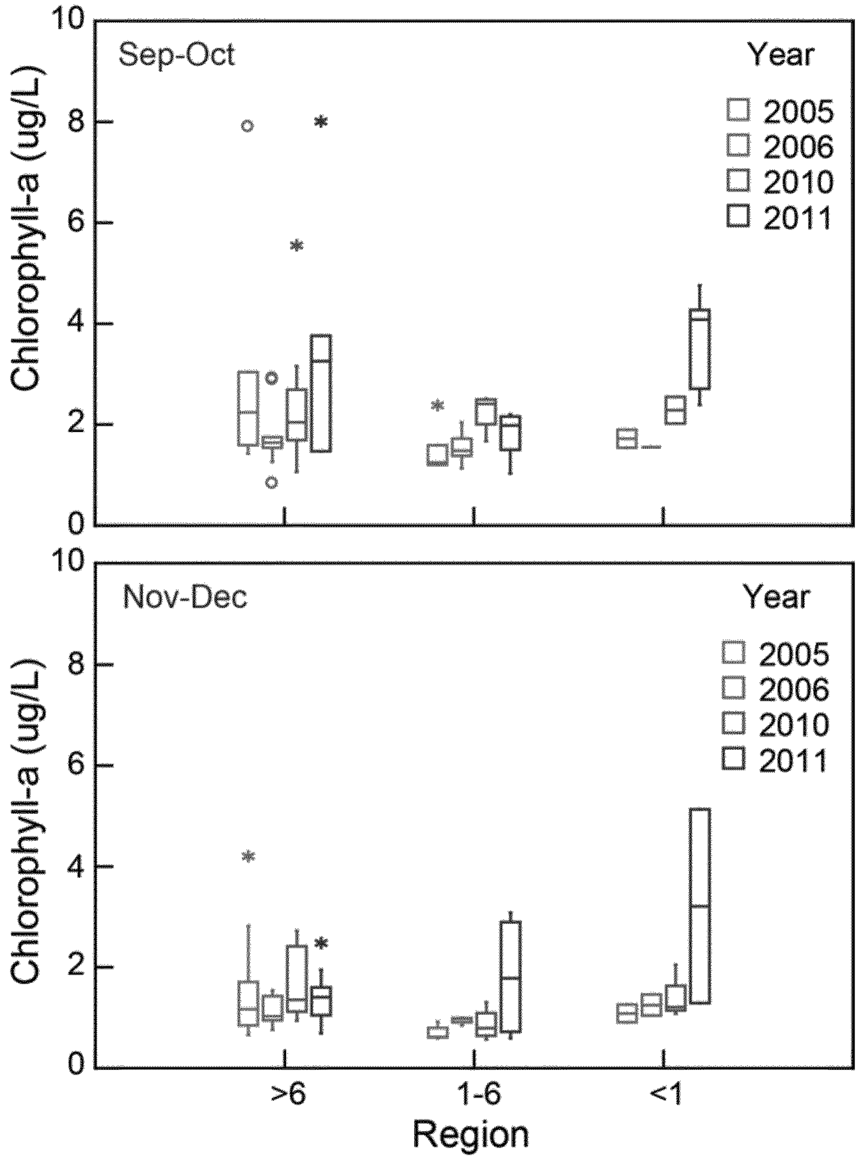

Figure 33. Chlorophyll-a concentrations in Sep-Oct and Nov-Dec from the IEP Environmental Monitoring Program (see Appendix A.6).

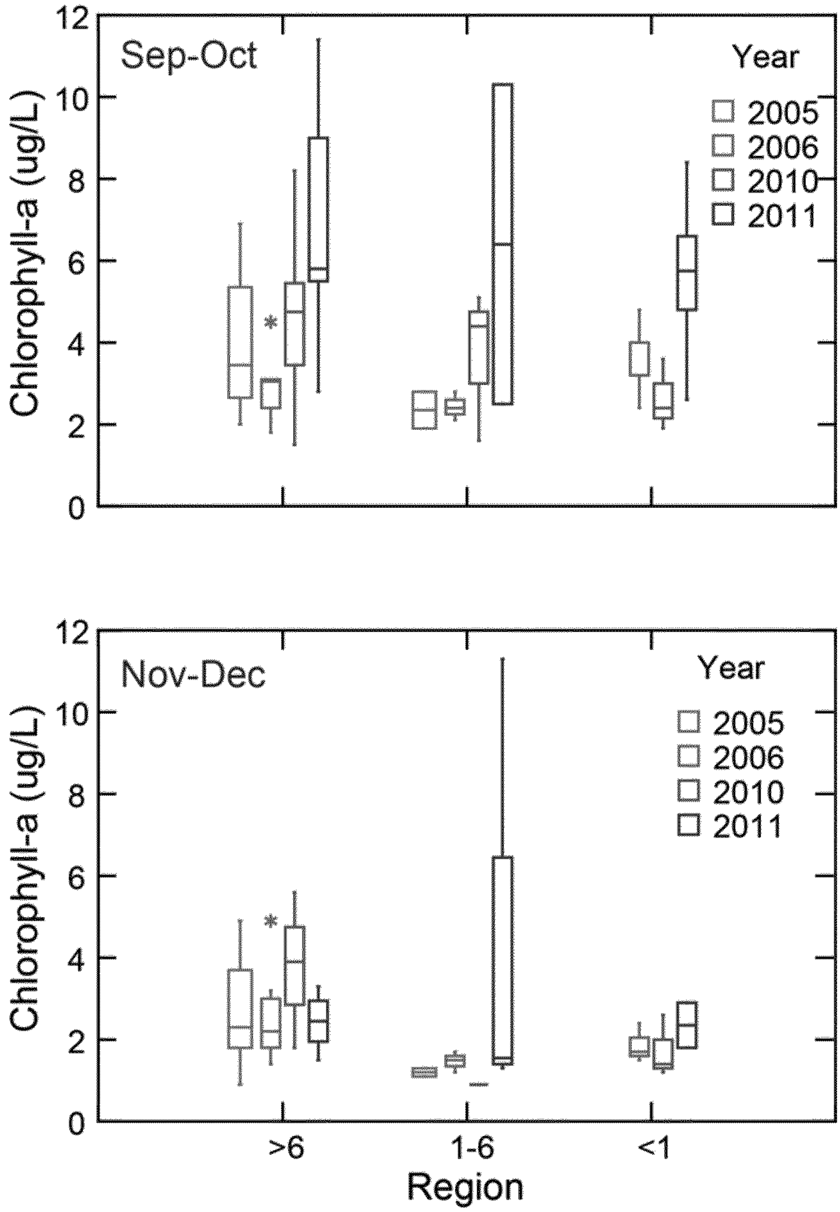

Figure 34. Chlorophyll-*a* concentrations in Sep-Oct and Nov-Dec 2011 from samples collected during monthly USGS cruises (see Appendix A.7).

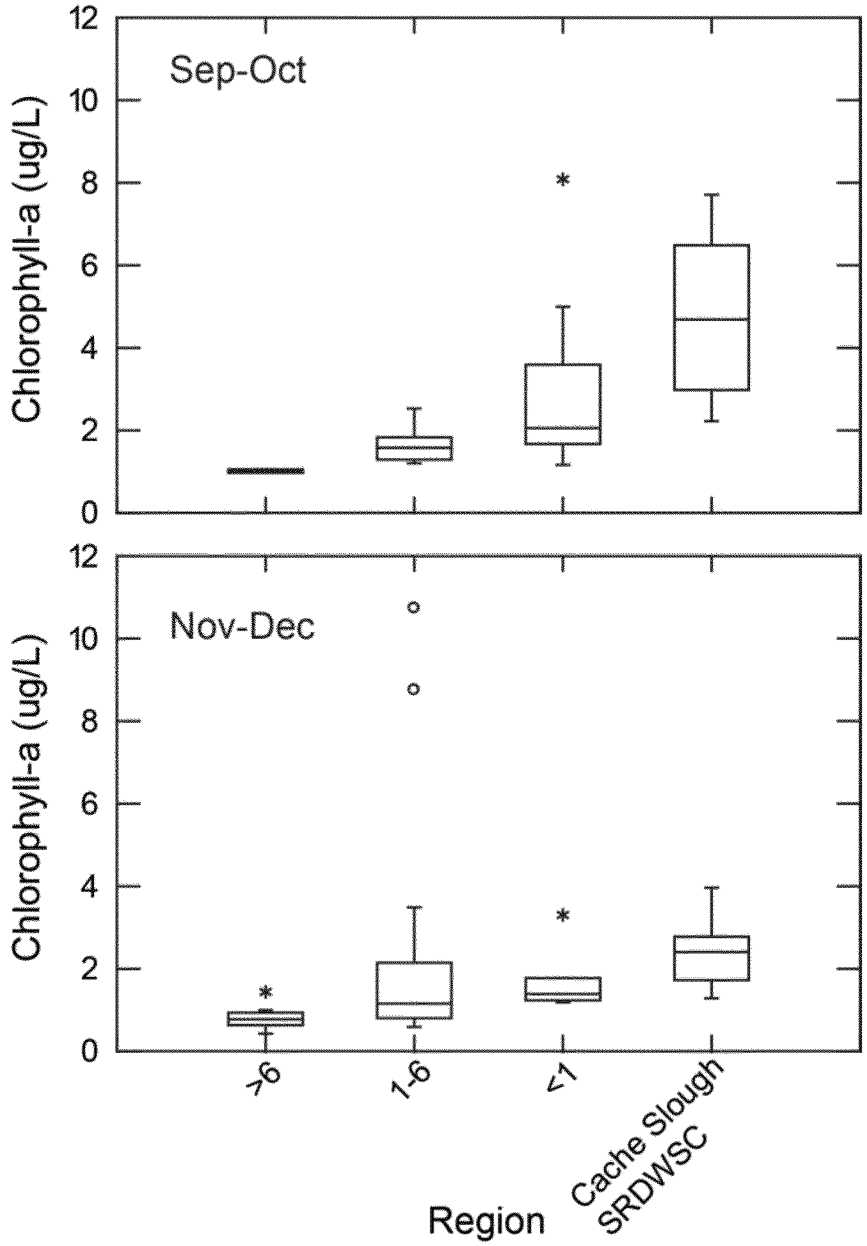

Figure 35. Chlorophyll-*a* concentrations in Sep-Oct and Nov-Dec 2011 from samples collected during the fall midwater trawl (see Appendix A.4).

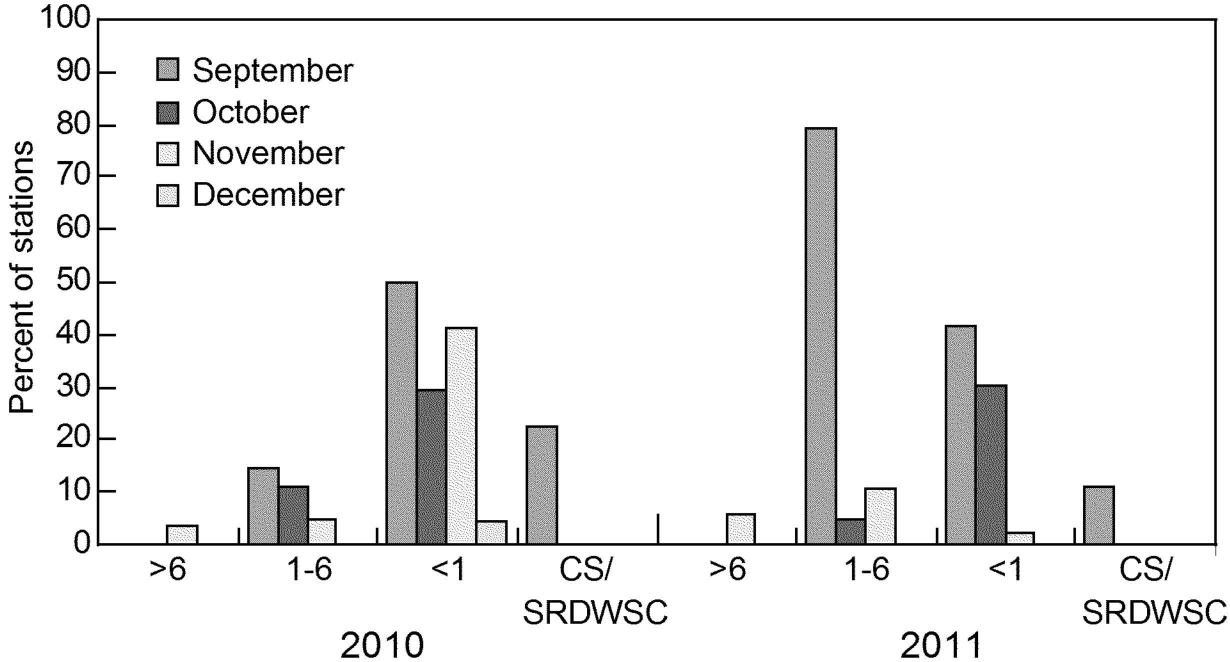

Figure 36. Occurrence of floating Microcystis at FMWT sampling stations for September to December 2010 and 2011.

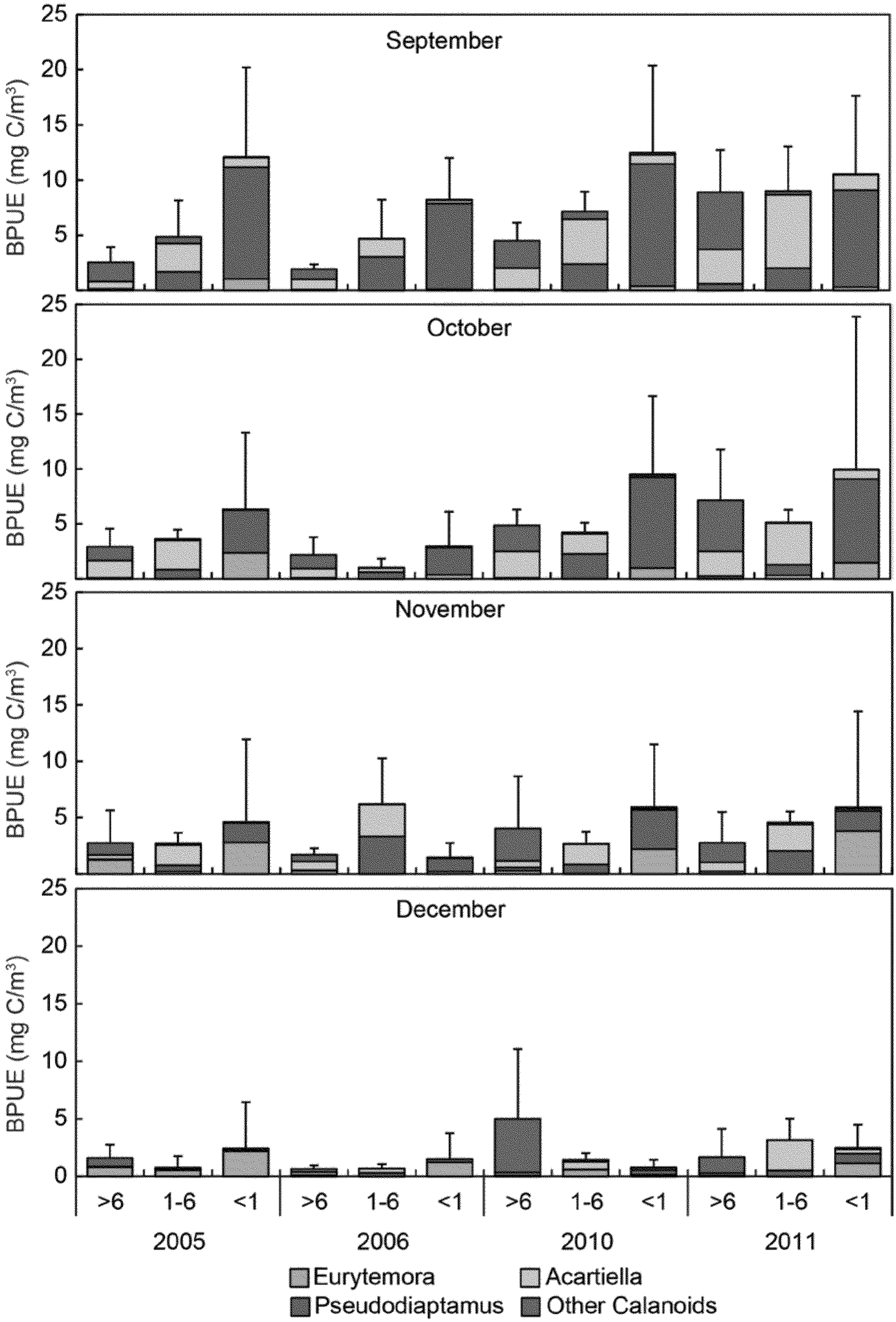

Figure 37. Biomass per unit effort (BPUE, mg C/m^3) of juvenile and adult calanoid copepods for EMP samples (mean ± 1 standard deviation).

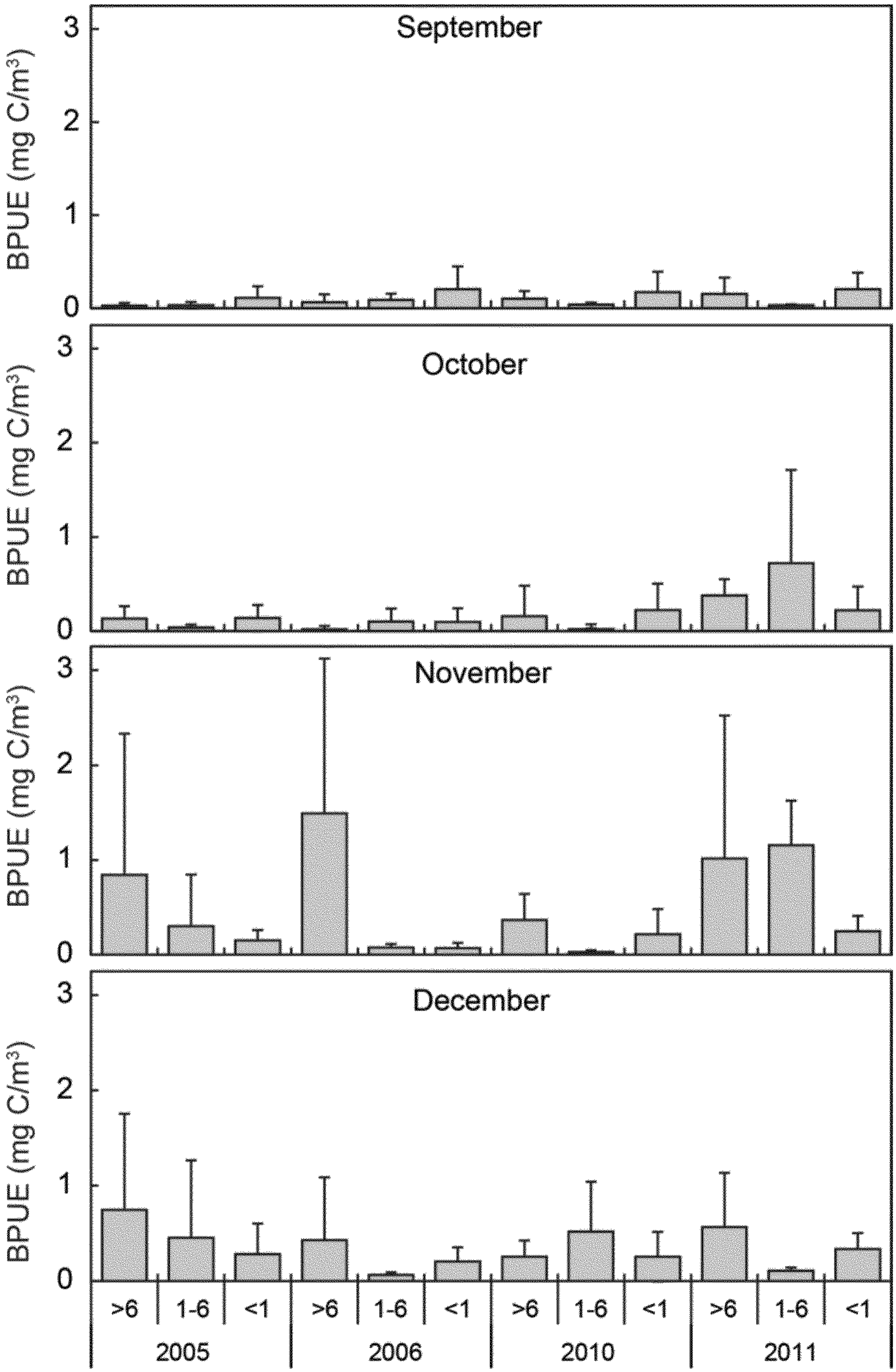

Figure 38. Biomass per unit effort (BPUE, mg C/m^3) of juvenile and adult cyclopoid copepods for EMP samples (mean ± 1 standard deviation).

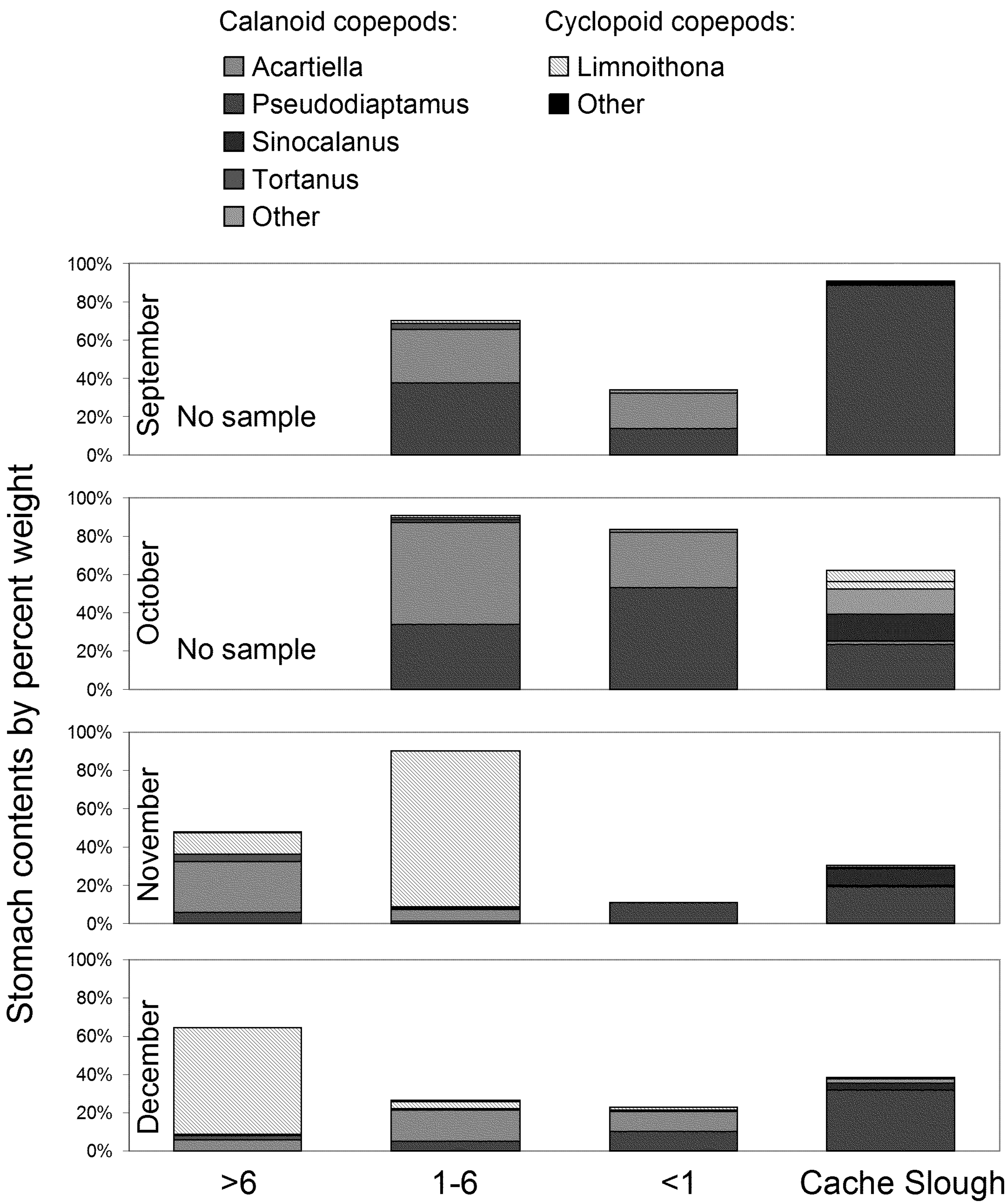

Figure 39. Stomach contents by weight (g) of calanoid and cyclopoid copepods for delta smelt captured in the FMWT in 2011. The composition of the remaining proportion of the diet is shown in Figure 40.

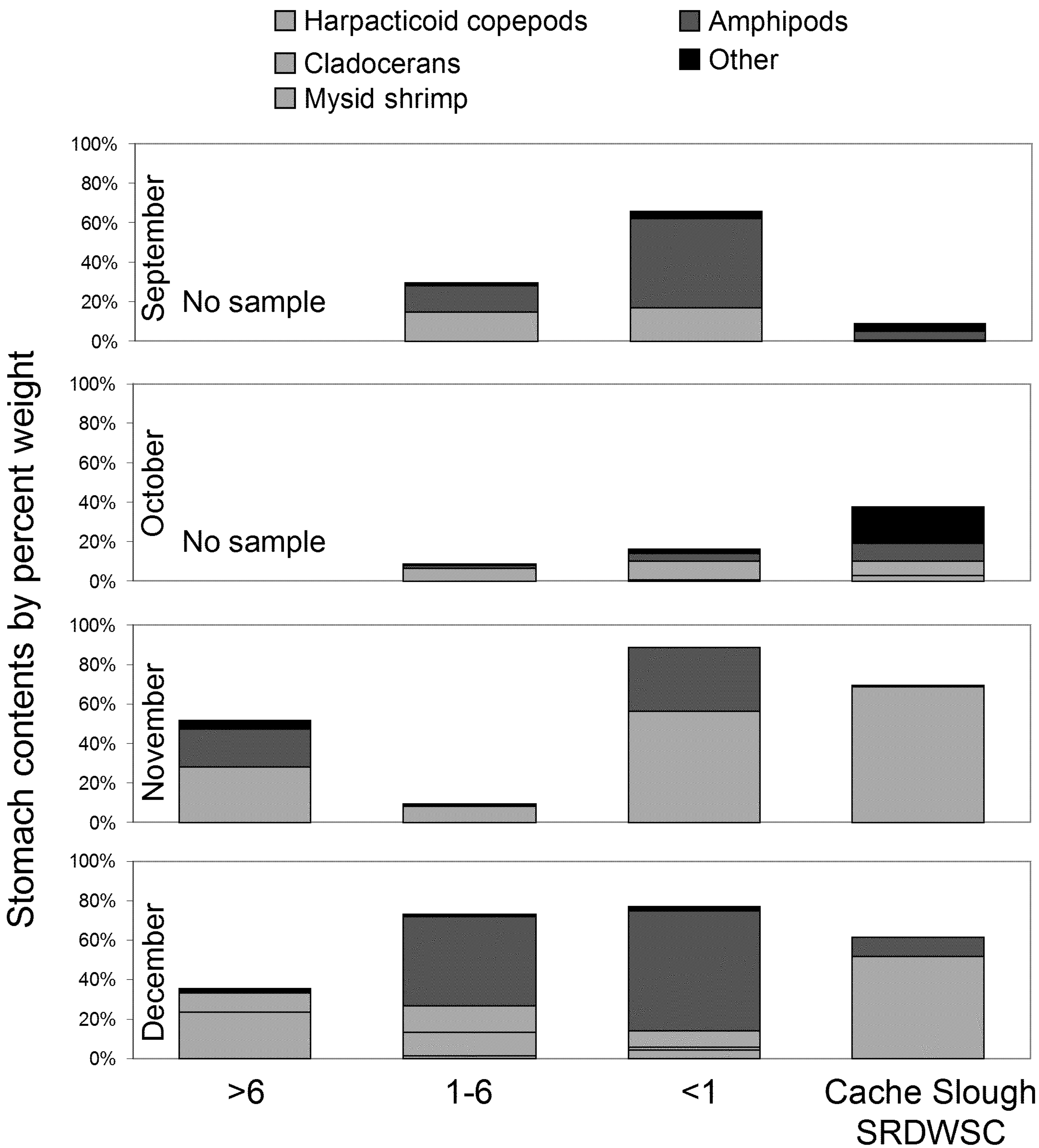

Figure 40. Stomach contents by weight (g) of items other than calanoid and cyclopoid copepods for delta smelt captured in the FMWT in 2011.

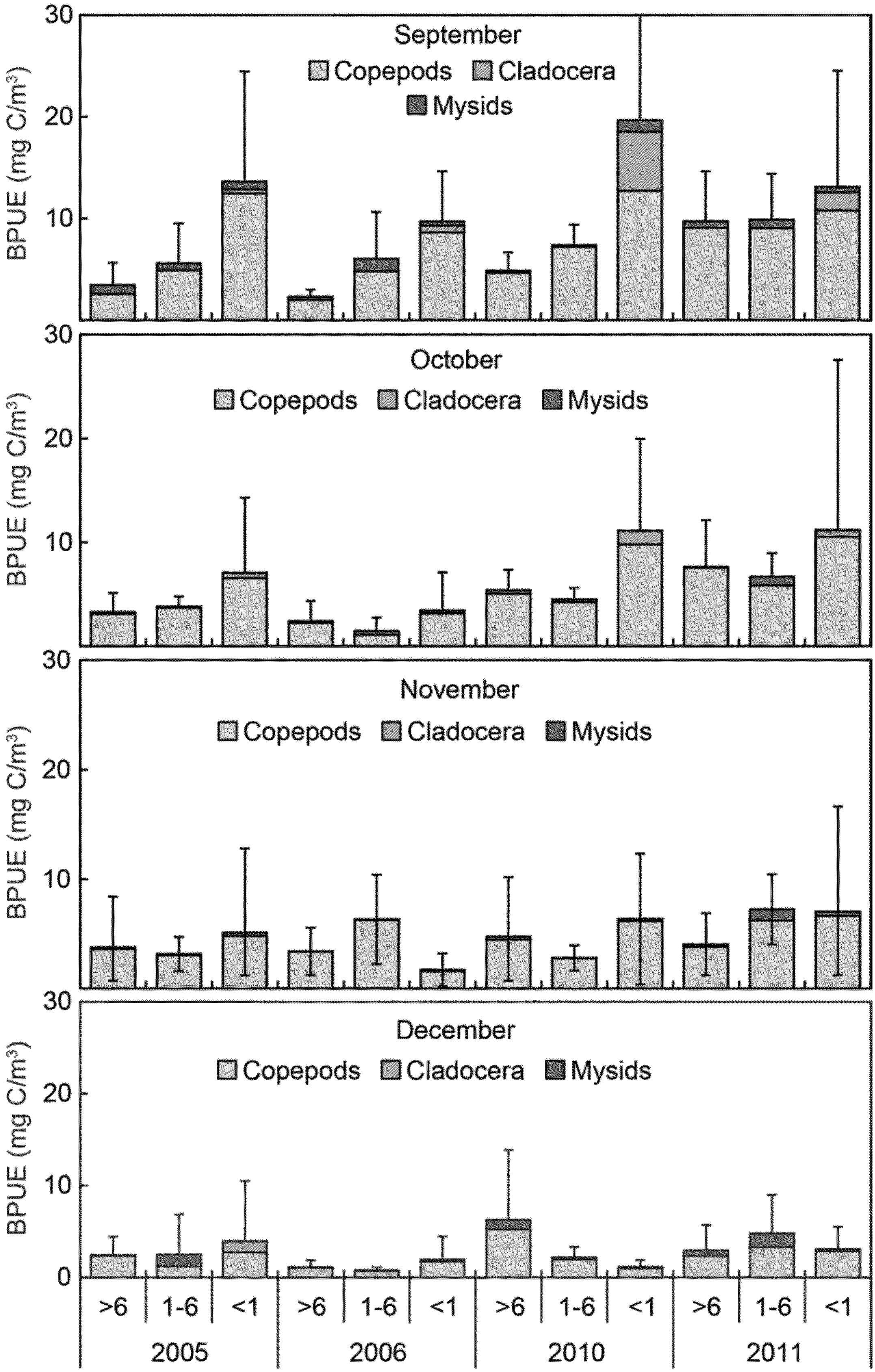

Figure 41. Biomass per unit effort (BPUE, micrograms of C m-3) of juvenile and adult calanoid copepods, cyclopoid copepods, cladocerans, and mysids for EMP samples (mean ± 1 standard deviation).

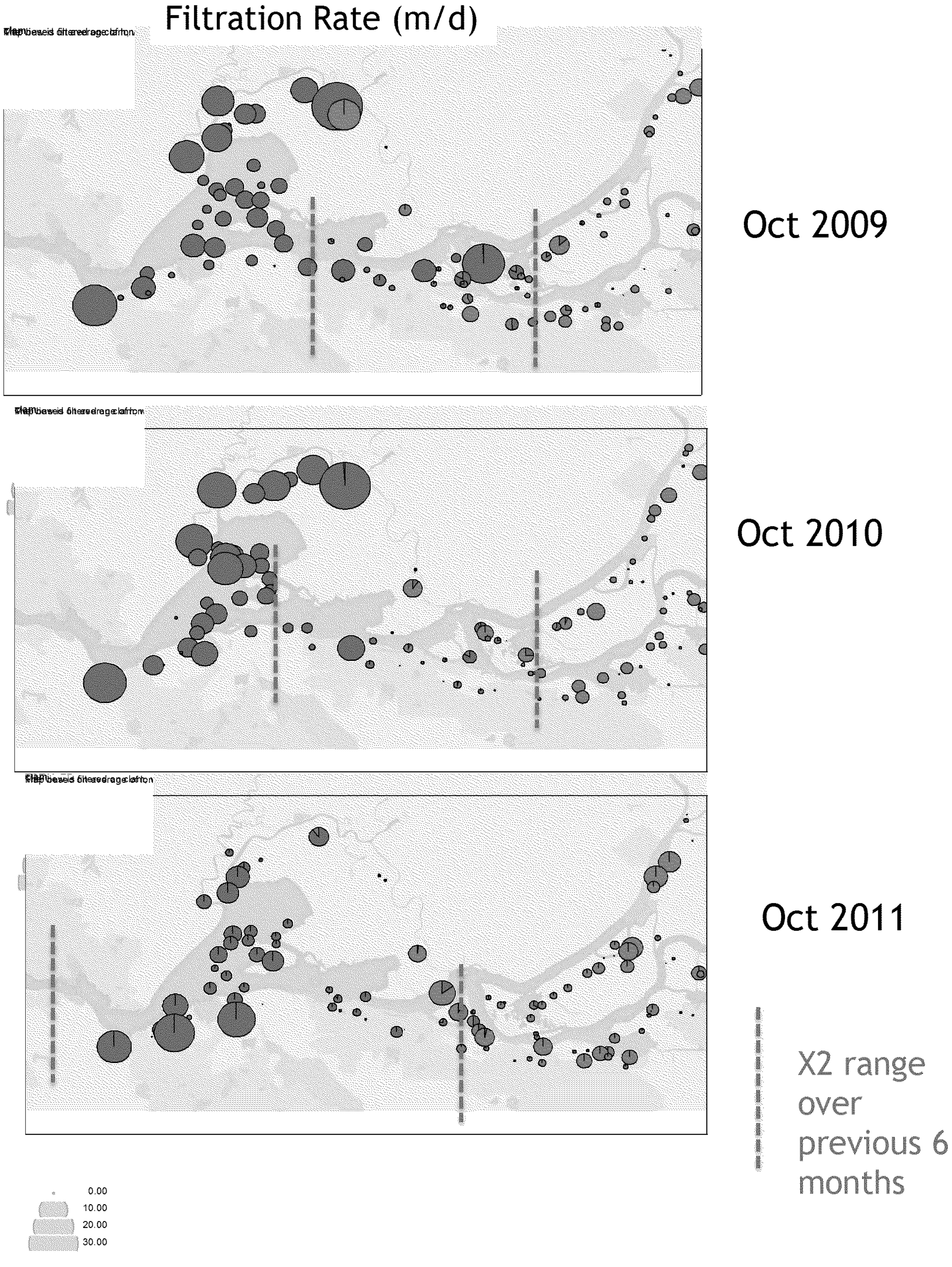

Figure 42. Filtration rate (a function of biomass and temperature) for both *Potamocorbula* (blue) and *Corbicula fluminea* (orange) in October 2009, 2010, and 2011. Range of X2 over previous 6 months shown on map as range where bivalves were expected to overlap.

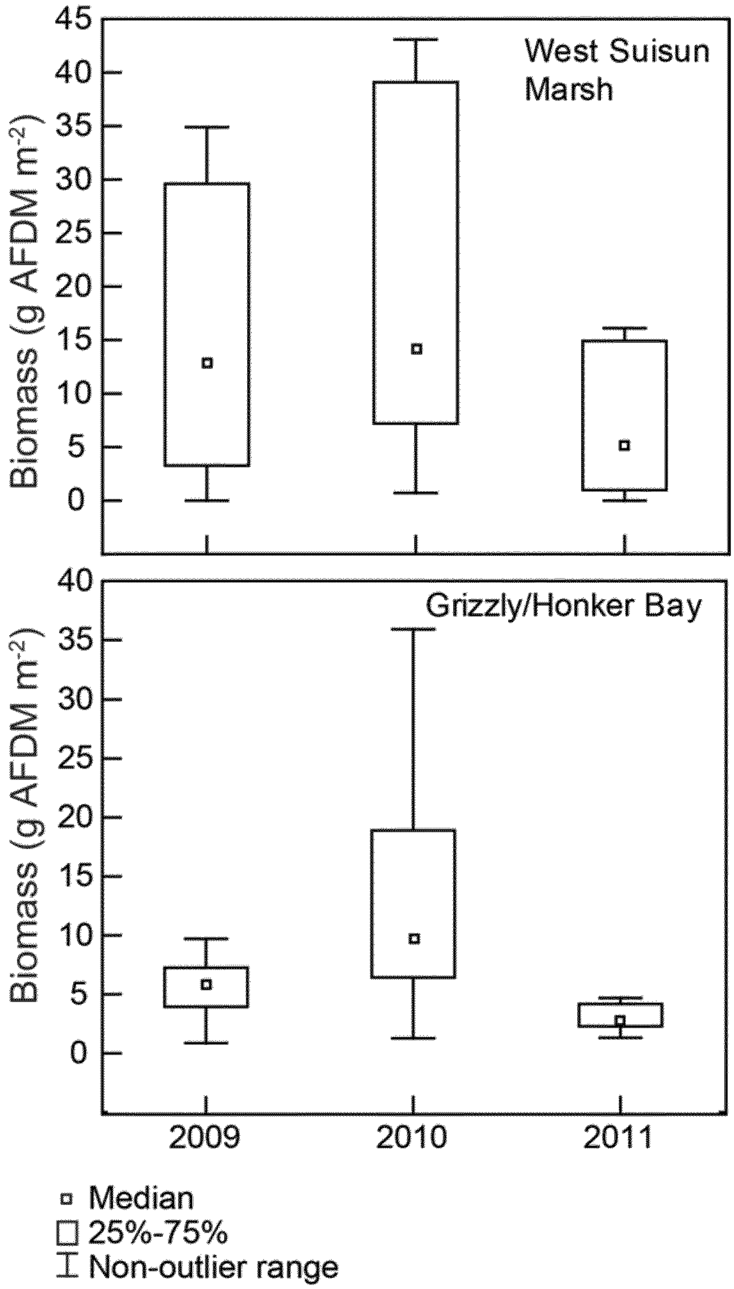

Figure 43. Biomass during the October sampling periods in western Suisun Marsh and Grizzly/Honker Bay shallows. Biomasses were not significantly different between 2009 and 2010 but were significantly different for 2010 and 2011 (Thompson and Gehrts 2012). Figure modified from Thompson and Gehrts (2012).

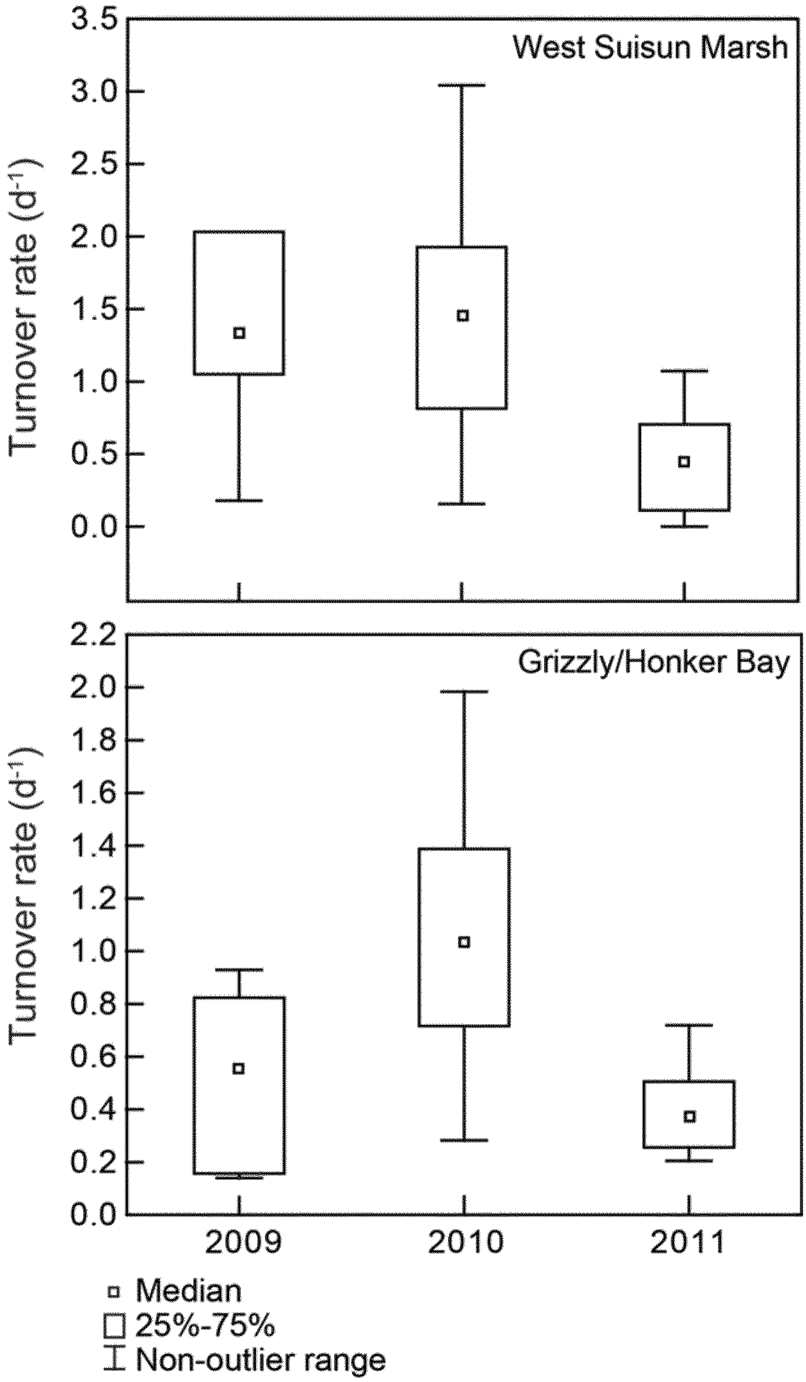

Figure 44. Turnover rate (d-1) during the October sampling periods in western Suisun Marsh and Grizzly/Honker Bay shallows. Biomasses were not significantly different between 2009 and 2010 but were significantly different for 2010 and 2011 (Thompson and Gehrts 2012). Figure modified from Thompson and Gehrts (2012).

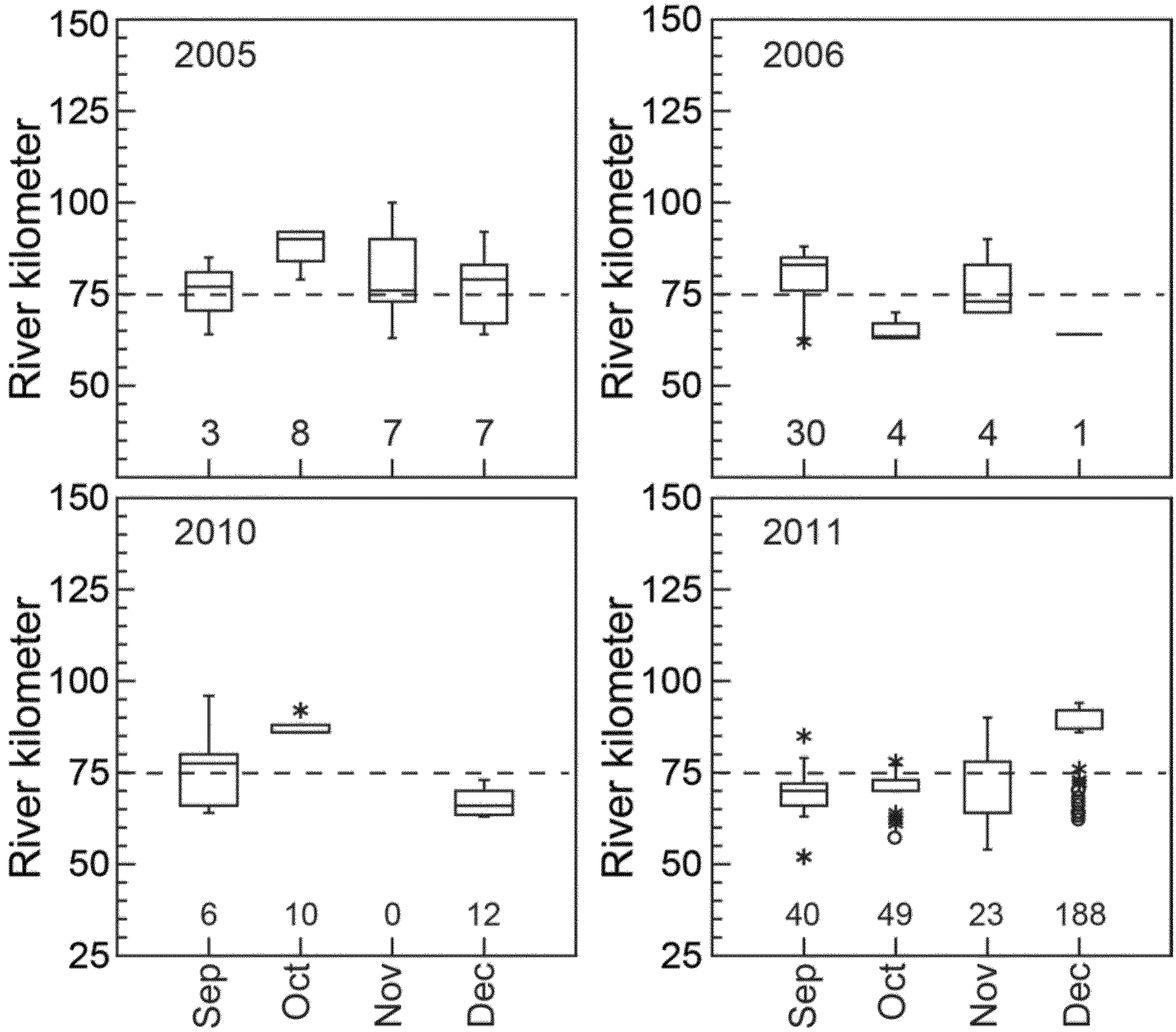

Figure 45. Distribution of delta smelt captured in the FMWT. The river kilometer of each site from the Golden Gate where delta smelt were captured was weighted by the number of delta smelt caught. Numbers of delta smelt captured each month is shown. The dotted line shows 75 km for reference.

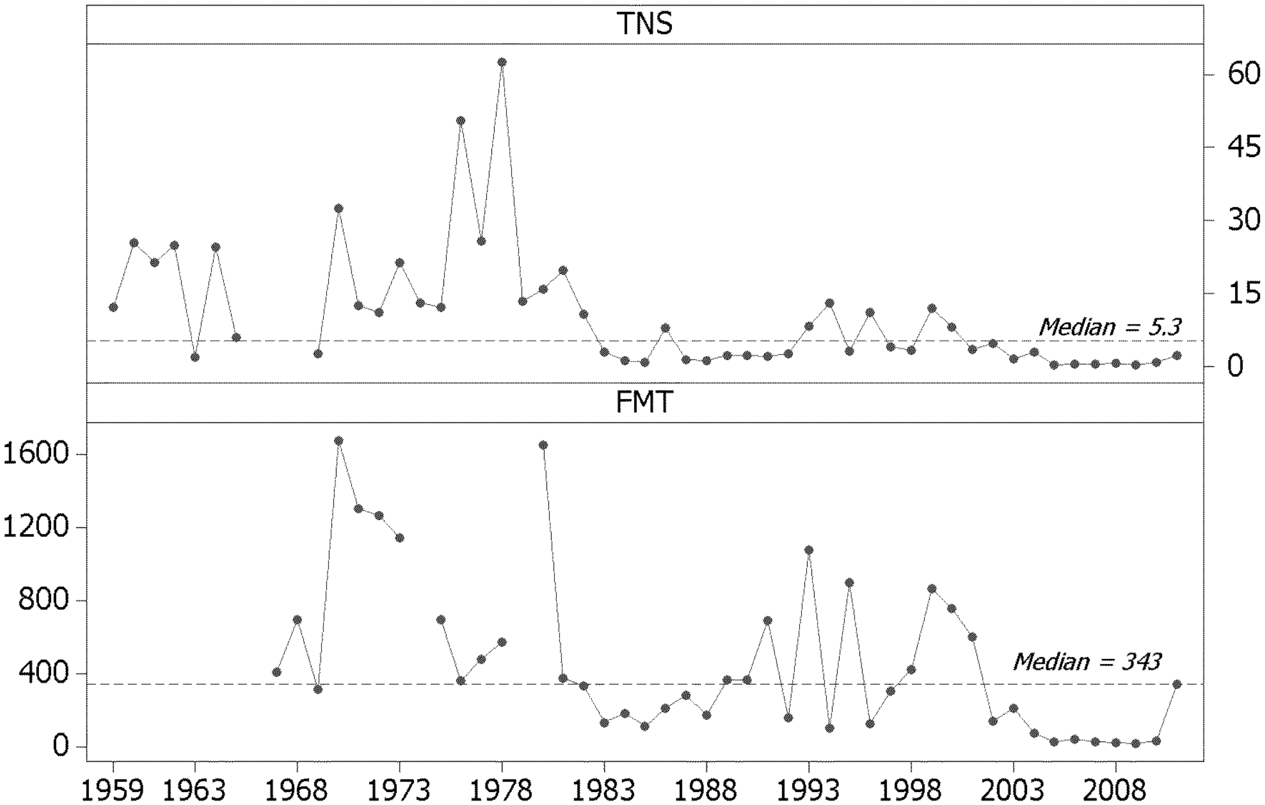

Figure 46. Plots of summer townet survey and fall midwater trawl delta smelt abundance indices by year. Data are available at http://www.dfg.ca.gov/delta/projects.asp?ProjectID=TOWNET and http://www.dfg.ca.gov/delta/projects.asp?ProjectID=FMWT, respectively.

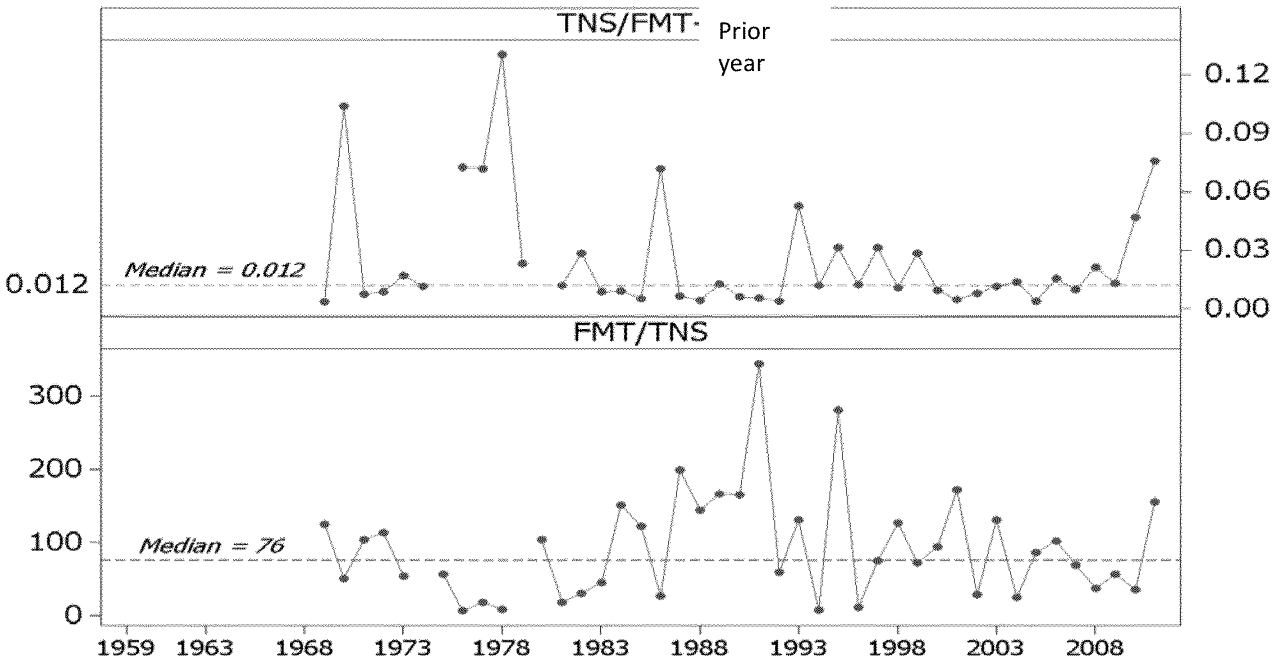

Figure 47. Ratios of delta smelt abundance indices used as indicators of survival.